NASA TECHNICAL TRANSLATION NASA TT F-15774

THE FOURTH NATIONAL CONFERENCE ON ACOUSTICS
VOL. III
PHYSIOLOGICAL, PSYCHOLOGICAL AND BIOLOGICAL ACOUSTICS

Acoustics Commission,
Academy of the Socialist Republic of Romania

Translation of A IV-a conferinta nationala de acustica. Vol. III. Acustica fiziologica, psihologica si biologica, Academy of the Socialist Republic of Romania, Bucharest, May 29-31, 1973, 237 pp.

(NASA-TT-F-15774) THE FOURTH NATIONAL CONFERENCE ON ACOUSTICS. VOLUME 3: PHYSIOLOGICAL, PSYCHOLOGICAL AND BIOLOGICAL ACOUSTICS (Kanner (Leo) Associates) CSCL 06S G3/04 41323

N74-26595

Unclas

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 MARCH 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15774	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle THE FOURTH NATIONAL CONFERENCE ON ACOUSTICS. VOL. III. PHYSIOLOGICAL, PSYCHOLOGICAL AND BIOLOGICAL ACOUSTICS		5. Report Date March 1974 6. Performing Organization Code
7. Author(s) Academy of the Socialist Republic of Romania, Acoustics Commission		8. Performing Organization Report No. 10. Work Unit No.
9. Performing Organization Name and Address Leo Kanner Associates, P.O. Box 5187, Redwood City, California 94063		11. Contract or Grant No. NASw-2481 13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of A IV-a conferinta nationala de acustica. Vol. III. Acustica fiziologica, psihologica si biologica," Academy of the Socialist Republic of Romania, Bucharest, May 29-31, 1973, 237 pp.

16. Abstract The articles in this collection deal with many of the medical, social, psychological and physiological problems raised by noise pollution. Such topics as the medical aspects of airport noise, noise-induced hearing losses in various industries, noise annoyance, etc. are discussed. There are also several articles on the biophysical and medical effects of utrasounds. See table of contents.

PRICES SUBJECT TO CHANGE

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	
Unclassified	Unclassified	

NASA-HQ

Table of Contents

	Page
MEDICOSOCIAL PROBLEMS RAISED BY SOUND POLLUTION G. Cadariu and A. Ionescu	1
ACOUSTICS ON OIL WELL DERRICKS; NOISE-INDUCED HEARING LOSS AMONG OIL WELL WORKERS D. Dahl, K. Dietzel, P. Hoff, and D. Kleinfeldt	11
STUDY OF THE DISPERSION OF PURE-TONE HEARING THRESHOLDS E. Teisanu and Ed Motas	17
THE STATE OF HEARING AND VESTIBULAR ORGANS AMONG PERSONS SERVING ULTRASONIC DEFECTOSCOPES I. Ratajaka and W. Sorozypscak	21
ADAPTATION PROBLEMS OF WOMEN TEXTILE WORKERS S. Girbea and M. Negulescu	27
INDIVIDUAL DIFFERENCES AND THE SOUND ENVIRONMENT IN OCCUPATIONAL ACOUSTIC TRAUMATISM L. Teodorescu, E. Stratulat, and I. Cornea	31
SOME ASPECTS OF THE RELATIONSHIP BETWEEN TEMPORARY AND PERMANENT HEARING THRESHOLD SHIFTS IN THE EVOLUTION OF OCCUPATIONAL HYPOACUSIA G. Mihail, D. Mocanu, G. Branisteanu, M. Vasilov, and E. Teodorescu	37
MEDICAL ASPECTS OF AIRPORT NOISE G. Clipici and G. Niculescu	44
CHANGES IN THE CRITICAL FUSION FREQUENCY THRESHOLD FOR INTERMITTENT LIGHT IMAGES AND THE MOTOR REACTION TIME OF WOMEN WORKERS IN SPINNING DEPARTMENTS C. Ursoniu, A. Dankner, and A. Sirbu	48
CLINICAL CONSIDERATIONS ON SOUND POLLUTION IN THE HUNEDOARA IRON AND STEELWORKS I. Malaiu, W. Nikels, C. Disconescu, and M. Bichis	54
ACOUSTICAL STUDY OF CONFORMATIONAL CHANGES OF NUCLEIC ACIDS IN WATER SOLUTIONS F.I. Braginskaya	59
THE BIOPHYSICAL EFFECTS OF ULTRASOUNDS ON CELL MORPHOLOGY I. Hrazdira	63
CHANGES IN THE STRIATED MUSCLE MECHANOGRAM UNDER THE ACTION OF NONCAVITATIONAL SOUNDS I.I. Nagy	68

Page

SPEECH UNDERSTANDING AND DISCRIMINATION OF SOUND SIGNALS IN THE CONDITIONS OF ACOUSTIC DISTURBANCE
Z. Bochenek, I. Ratajska, M. Zdrojewska-Turosienska, and J. Dawidowicz 74

EFFECTS OF ULTRASONICS ON CHANGES IN BIOLOGICAL PROPERTIES OF BAKER'S YEAST
F.I. Braginskaya, K.Ye. Kruglyakova, V.A. Yermachenko, and T.V. Rusanova 80

MATHEMATICAL MODEL OF THE ULTRASOUND EFFECT ON RED CORPUSCLES
E. Veress and J. Vincze 84

ULTRASONIC THERAPY IN OTORHINOLARYNGOLOGY
M. Ionescu, M.D. Nicu, and L. Ionescu-Ghermanescu 89

ULTRASONIC THERAPY IN MEDICAL RECOVERY FROM DEGENERATIVE RHEUMATIC AFFECTIONS OF THE VERTEBRAL COLUMN
C. Craciun, E. Morariu, P. Pusca, and V. Mares 97

THE RELATIONSHIP BETWEEN TONE AND SPEECH PERCEPTION IN CASES OF NOISE-INDUCED HEARING LOSS
G. Tymnik and H. Beyer 106

NOISE ANNOYANCE: A PSYCHOPHYSIOLOGICAL VIEW
E. Gulian 111

EFFECT OF THE DURATION OF VIBRATION EXPOSURE ON LATE CHANGES IN THE ACTIVITY OF SOME OXYREDUCTIVE ENZYMES IN THE RAT KIDNEY
E. Ivanovici, G. Antov, M. Zlateva 117

EVALUATION OF OCCUPATIONAL NOISE AND ITS SPECIFIC EFFECTS IN VARIOUS INDUSTRIES
D. Mocanu, G. Mihail, and V. Popovici 122

IMMUNOELECTROPHORETIC CHANGES IN SERUM PROTEINS IN RESPONSE TO HIGH-FREQUENCY VIBRATIONS
S. Zwetkov and B. Petrounov 130

INVESTIGATIONS OF EXPOSURE TO VIBRATIONS IN COAL MINES
H. Horman and G. Dirlea 138

RESULTS OF A SOCIOLOGICAL SURVEY OF THE EFFECT OF AIRCRAFT NOISE ON RESIDENTS NEAR OTOPENI AIRPORT
S. Hetcou 148

SIGNIFICANCE OF OCCUPATIONAL NOISE EXPOSURE IN A WIRE NETTING MANUFACTURING DEPARTMENT
C. Ursoniu, A. Dankner, I. Bodea, and A. Sirbu 157

Page

EXPERIMENTAL RESEARCH ON THE ROLE OF AMPLIFIER OF THE BULLA TYMPANICA IN ANIMALS
D. Holicska and Z. Kis 162

ASPECTS OF SOUND AND VIBRATION POLLUTION WITH PATHOLOGICAL IMPLICATIONS IN PRAHOVA COUNTY
A. Stefaniu and G. Caluschi 166

INVESTIGATION OF CITY NOISE IN TIRGU MURES
P. Horvat, E.I. Farkas, I. Steinmetz, A. Bodis, W. Lücke, B. Ember, and P. Ney 171

INFLUENCE OF NOISE ON RHEOENCEPHALOGRAMS
J. Grubereva, and I. Zalcik 174

MEDICO-SOCIAL PROBLEMS RAISED BY SOUND POLLUTION

G. Cadariu and A. Ionescu
Institute of Hygiene and Public Health,
Bucharest, Romania

Noise is one of the factors that go to make up the environment in which man's life and activities unfold. /9* The quantitative and qualitative characteristics of noise place it at both ends of the limits that define optimal living conditions in the sense that a certain amount of noise or, rather, a certain value of the sound environment, is necessary for the normal unfolding of life but, on the other hand, under many circumstances noise disturbs the individual's comfort and even his state of health. The latter assertion refers to the universally recognized fact that noise in excess of certain limits of intensity becomes a factor of biological aggression, a medico-social noxa with implications of the greatest importance for our state of health and working capacity. Today, the problem of the harmful effects of noise is assuming a note of extreme urgency, a note with social overtones that are becoming increasingly apparent as the radius of action of noise is extended, which is itself a natural consequence of those processes which characterize modern society, namely: urbanization, motorization, industrialization. This results, on the one hand, in a rapid increase in the number and power of noise sources in the urban as well as the industrial environment and, on the other, an increase in the number of individuals who endure the rigors of noise, with /10 all the attendant harmful effects that can be ascribed to it. We do not hesitate to assert that with the present state of organization of social life, a great number of members of the human collectivity are potential victims of noise, successively exposed as they are to the three categories of noise: occupational noise, urban noise and residential noise. In illustration of our assertion about the social overtones that noise is tending to acquire on account of its extension, we shall take the liberty of citing a few conclusions from a study we undertook in 1970, a study that aimed at investigation of sound pollution in the city of Bucharest from the standpoint of industrial as well as urban noise.

From the standpoint of industrial noise: in the majority of enterprises that we investigated there exist work spaces and technological processes which entail the generation of noise levels that exceed the maximum permissible limits for biological safety;

-- as a consequence of this pronounced extension of noise through intrafactory sound pollution, an alarming number of workers employed in different industrial sectors are presently working under conditions of exposure to high

*Numbers in the margin indicate pagination in the foreign text.

noise levels;

-- if our criterion for hierarchization of different industrial sectors is the number of workers working under noisy conditions, the most acute problems are raised by machine-building plants, metallurgical works and light industries.

From the standpoint of urban noise the principal sources are transportation, industrial enterprises, urban construction and reconstruction projects, household activities. Our attention was /11
concentrated on investigation of the noise produced by street traffic, which already constitutes the principal noise-generating factor in the urban environment. The mean noise values that we found (about 70 dB by day and 60-65 dB by night) do not exceed the critical values measured in other large metropolises. It should be noted, however, that the present noise level is not justified by the intensity of traffic which, under similar conditions in other countries, generates lower noise levels. We believe that the explanation resides in the technological state of the vehicles and of the street network. It also emerged from our studies that the level of noise generated by street traffic is influenced by the geometric structure of the arterials and by the mode of organization of the traffic. On arterials with tall buildings forming a continuous front noise is amplified, the mean level appearing higher than would be justified by the traffic. As far as the mode of organization of traffic is concerned, it should be noted that at rotary intersections the noise level is more uniform (extreme variations are rarer) than at intersections with traffic signals, where the flow of traffic is interrupted by repeated accelerations and decelerations. Generally speaking, our present street system, which was designed and dimensioned for an incomparably smaller volume of traffic, is nowadays confronted with a veritable avalanche of motorized means of transportation, which causes the urban sound environment to attain ever more alarming levels. Nor must we neglect the fact that sonic insulation of apartment buildings entails an increase in the noise level inside the apartments because of the increased percolation of street noise and the transmission between the different functional units of the noise /12
generated by household activities. The increase in the level of street noise and, implicitly, of residential noise magnifies in an alarming manner the social consequences of noise by extending the radius of action of this noxa over practically the entire population, including those who are not integrated into noisy productive activity (such as infants, old people, housewives, invalids). Nor, in judging of the real social noxiousness of urban noise, must we lose sight of the fact that the active population (those who are integrated into productive activity) are assailed by noise just when they are looking for rest and relaxation, which encroaches upon the organism's means of recuperating its functional capacities. Certainly we are witnessing a veritable offensive of sound aggression against citydwellers,

and offensive which we believe has its roots in the obvious discrepancy between the rapid increase in the number and power of noise sources and our present technological means of combating noise. On the basis of our own data and those of other authors, which compel recognition of noise as one of the principal noxae of modern life, we accorded particular attention to studies of this problem in terms of a complex approach, our investigations being directed toward the study of the local as well as the general effects of noise. The local or specific effects are caused by the action of noise on the auditory apparatus and are directly conditioned by the physical parameters of the noise: its intensity and spectral composition. With reference to the local effects, our attention is attracted in the first place by the prolonged action of noise (the case of occupational exposure), which is expressed in irreversible morphofunctional changes in Corti's /13
organ, changes which lead to the setting in of pronounced and persistent hearing losses resulting in a clinical picture of occupational deafness. Through the setting in of deafness the organ of hearing loses one of its most important functional properties, namely, the plasticity of change in the hearing threshold as a function of the physical value of the sound environment, a plasticity which underlies the adaptation of hearing to the variable conditions of the sound environment. Actually, the organic cochlear lesions that are characteristic of occupational deafness are equivalent to a definitive fixation of the hearing-threshold at a level corresponding to adaptation to the physical conditions of the occupational sound environment. As a result, when the individual leaves the occupational environment and enters the social environment, which requires the threshold to return to values permitting the reception of sound stimuli having a much smaller physical value, he is handicapped by the loss of plasticity of the threshold-modifying mechanisms. Thus deafness constitutes an obvious social handicap. Inasmuch as the data on occupational deafness have in general been widely discussed, we shall not dwell upon them. What we do wish to emphasize, however, are some considerations of a theoretical and practical order emerging from our audiometric study of workers in a machine-building plant, considerations that are important for the sketching of the social aspect of the problem as well as for the implementing of a prophylactic policy capable of counteracting the hearing impairments ascribable to occupational sound pollution. What is to be noted from the social standpoint is the very high incidence of occupational deafness: 44.71% of the 476 workers investigated, i.e., practically half of the total number of workers exposed to /14
noise. What is to be noted from the medical standpoint are two aspects necessary for practical prophylaxis, namely:

-- the setting in of deafness in subjects with a low average exposure time: 11.94% of the subjects from the group with an average length of service of only 1.03 years and, on the other hand:

-- the absence of manifest deafness in about 30% of the subjects from the group with an average length of service of 26.5 years.

These aspects testify to the existence of great individual differences in susceptibility to noise and, from the practical point of view, raise the problem of the active ferreting out of these differences with a view to instituting rigorous individual protective measures as well as with a view to refusing to hire those who are susceptible. Returning to the social aspect, we should like to stress the very pronounced incidence of deafness ascribable to noise, an incidence which testifies to the existence of a causal relationship between sound pollution and loss of hearing. Our firm belief in this relationship is supported by the results of many another study and investigation. Let us cite a few of the more significant ones:

-- the population of large towns shows losses in hearing acuity that are particularly pronounced as compared with the population of environments that are noiseless and isolated "from the benefits of modern civilization" (Rosen), in whom hearing remains unimpaired until an advanced age;

-- in Sweden only one out of four machine-building workers has normal hearing;

-- in the German Federal Republic the place of deafness on the roster of occupational diseases has moved from the seventh place in 1967 to the fourth place in 1969;

-- in the German Democratic Republic between 1963-1965 hypoacousias accounted for 43% of the total number of recognized and declared occupational diseases; in 1966 they accounted for as much as 51%. /15

-- in the USA the increase in the percentage of hypoacousias of different degrees has kept pace with industrialization, and Bell estimates that 8-10 million Americans were obliged to use hearing aids in 1958.

All authors agree that the explanation for this increase in the number of individuals with impaired hearing is largely to be found precisely in the two above-mentioned aspects, which compel recognition of noise as a social noxa of the first magnitude, namely: the increase in the physical level of the sound environment and the extension of noise's radius of action over the population. Of course, the medico-social implications of organic modifications are more spectacular and so they clamor for the attention of all investigators. We believe, however, that no less important are

local subclinical effects caused by the action of noise on the organ of hearing. We have in mind the masking effect and the effect of inducing the state defined as auditory fatigue. Of minor importance though these aspects, which we have investigated under experimental laboratory conditions, may appear at first blush because of their transitory character, actually they entail particularly practical consequences because of the jamming effect they have on communication possibilities. Interhuman communication by means of language is possible to the extent that the sounds which contain the verbally coded message can be perceived distinctly and correctly; in other words, the quantity and quality of information depend on the intelligibility of the information-bearing symbols the message is made up of. Informational symbols can be perceived distinctly and correctly, i.e., can constitute a sequence of informative symbols, only to the extent that they exceed the environment's background noise. In order to be /16
perfectly intelligible, the useful sound symbol must exceed the background noise by at least 9-10 dB; otherwise, the noise will mask the sound signal, interfering with the intelligibility of the message. By jamming communication, noise abolishes one of hearing's most important functions, namely, the informational function. As a direct result of this effect, the individual is placed in a true state of confusion and tension, with unfortunate repercussions on his working capacity and psychic comfort as well as on his physical well-being: noise invites accidents by impeding the reception of acoustic warning signals. In this context the masking effect is today regarded as one of the most serious harmful effects ascribable to noise. Communication jamming is acquiring ever greater significance in view of the environmental noise level's constant tendency to increase. With regard to the transitory effects of noise, we cannot fail to make mention of the prognostic value of study of the temporary rise in the hearing threshold under a given configuration of the sound environment. According to data communicated by Ward and Kylin, it appears that there exists a direct relationship between the magnitude of the temporary rise in the hearing threshold produced by 8 hours of occupational exposure to noise and the magnitude of the definitive hearing losses induced by prolonged exposure to the given noisy environment. In other words, we can predict the auditory future of a worker exposed to noise on the basis of the rise in the hearing threshold after a day's work in the given environment. The exceptional importance of this observation from the standpoint of preventive medicine is obvious.

As far as general effects are concerned, it can be said that /17
today, after having been underestimated or even ignored for a long time, the general consequences that the sound avalanche can have for the organism are coming in for reconsideration and intensive study. The medical world is tending more and more to attribute to the damage ascribable to general effects a medico-social importance at least equal to that of chronic local effects.

The seat of the general effects is considered to be at the level of the upper neurons of the acoustic pathways, neurons that contract connections with the most varied structures, which makes it possible for noise to compete in regulating the general level of the CNS, to influence the neurovegetative and endocrine system, and to interfere with the individual's emotional life. In the context of the general influence of noise an ever greater number of clinical and experimental studies are drawing attention to the great prevalence of neuroses, neurogenetic hypertensions, digestive diseases, etc. under the chronic stressing action of noise. One of the directions in which our studies of the general effects of noise was oriented deals with investigation of the cardiovascular effects ascribable to this physical noxa. This choice was dictated, on the one hand, by the results of a study we carried out in a machine-building plant, which showed an increase by a factor of 1.33 in the incidence of cardiovascular diseases in noisy as compared with unnoisy sections and, on the other, by the data in the literature that hold noise responsible for a cardiovascular effect; in this particular case, a hypertensor effect. The results of our studies (carried out under laboratory conditions) brought to light temporary changes in some of the cardiovascular and hemodynamic parameters investigated; these can be summarized as follows:

-- an increase in the duration of the ventricular systole and diastole; /18

-- an increase in minimum blood pressure and a drop in the differential;

-- rheographic changes that indicate a state of spasticity in the peripheral vascular territory.

These experimental data confirm the existence of a general cardiovascular action ascribable to noise and give grounds to suspect the existence of a causal relationship between noise and cardiovascular pathology, permitting the transitory functional disorders observed under the conditions of the crucial experiment to become permanent and chronic under conditions of chronic exposure. Especially important from the standpoint of the practical implications of this causal relationship between noise and cardiovascular pathology are the conclusions of studies indicating that even noise that is catalogued (and therefore judged by the individual to be harmless), though it rapidly loses the effect of conscious annoyance, continues to act on the structures at the base of the brain and on the neurovegetative centers [8]. In this connection, Lehman has demonstrated that a noise below the conscious level of annoyance is nevertheless capable of causing a peripheral arterial and capillary vasoconstriction that is exerted throughout the duration of the noise's action, even though the noise may be accepted by the individual and judged to be unannoying.

The general intervention of noise through the neurovegetative system, in the particular case, through the principal chemical mediators of this system (adrenaline and noradrenaline), mediators that play an important role in the activity of the reticular substance, of the endocrine system and of numerous metabolisms, inspired us to undertake biochemical investigations that might disclose possible enzymatic perturbations induced by mechanical oscillations. Investigations of the carbohydrate metabolism have /19
shown an increase in activity of serous aldolase in workers exposed to the action of mechanical oscillations. In our opinion these changes are due to the following factors: owing to the vasoconstriction caused by the mechanical oscillations and to the corresponding reduction in blood irrigation, the lactic acid resulting from the muscular activity necessitated by occupational physical effort is accumulated to a pronounced degree. The consequent state of acidosis brings about serious biochemical disorders that go as far as compromising the intracellular structures to which the inactive aldolase is fixed, thereby releasing it into the circulation. At the metabolic level the ischemic effect and the consequent state of acidosis encroach on the normal unfolding of carbohydrate metabolic processes because ischemia affects the respiration of glycogen and phosphoric ester reserves while the state of acidosis, by altering the pH, interferes with hexokinase and alkaline phosphatase activity (optimum pH between 8 and 9). Also very probably involved in the pathogenic chain is the thyroid hyperactivity which is connected with prolonged stress conditions and which, on the one hand, reduces the glycogen reserve still further and, on the other, induces mitochondrial lesions through thyroxine. Affected by these lesions are the oxidative phosphorylation processes at this level, which inhibits the transport of the Mg ions necessary to the hexokinase activation process. The results of enzymatic investigations suggest the existence of perturbations at the level of the carbohydrate metabolism, perturbations which may provide some objective biochemical support for the classical phenomena of fatigue, nervous exhaustion and drop in physical and intellectual working capacity under conditions of exposure to the action of mechanical oscillations. The diversity and wide extension of the general effects brought to light by medical research especially in recent years /20
provide sufficient grounds for an understanding of the substantial contribution that noise may make to the appearance and aggravation of nervous, cardiovascular, digestive, endocrine and other general pathologic affections.

We believe that this succinct survey is as suggestive as can be in demonstrating the present and future importance of the problems connected with noise. It is obvious that at the present stage of development of society, noise has become one of the principal noxae of modern life, with far-reaching and serious implications for the individual as well as for society as a whole.

Under these conditions we concur with what we consider to be the perfectly justified opinion of specialists from the most diverse domains of activity, who are unanimous in drawing attention to the necessity of coordinating and canalizing our efforts toward fundamental and applied studies with a view to finding efficient means and methods of combating noise and its harmful effects. Our intention in broaching studies of the harmful biological effects of noise, however, was not just to confine ourselves to simple enumeration of the data of the problem, but to contribute actively to its solution. Inspite of general skepticism, we believe that it is possible to step in with effective measures and, although our studies have not been concluded, we have begun to sketch a point of view in this connection. In essence we believe that, without denying the priority of combating noise at its source, what is called for is a change in the practical approach to the problem of combating the harmful effects of noise, a change aimed at reconsidering the relationships between the technological and medical aspects of the fight against industrial noise in terms of the present state of our knowledge. A judicious /21
prophylactic program organized on the basis of the latest scientific findings can make up for the inherent present and future shortcomings of waging the fight against industrial noise on the technological front. Such a program will have to take into consideration the following:

-- drawing-up of unified criteria for the identification of occupational hypoacousias;

-- inclusion as part of the prehiring medical examination of specific tests for the detection of auditory weaknesses;

-- reconsideration of the periodic audiometric examination in such a manner as to permit the detection at the proper time of cases with an evolutive tendency toward deafness;

-- checking of the employment of individual protective measures and differentiation among types of protection as a function of sound environment and susceptibility to noise;

-- utilization of drugs for increasing the resistance of the organ of hearing in the teeth of the traumatizing action of noise.

Our firm belief in the practical efficiency of such a prophylactic program is based on our own data as well as on similar experiments reported from other countries. In conclusion, we express our conviction that an essential contribution to the realization of the final goal -- the protection of society against this veritable modern scourge that noise constitutes -- will be

made by the collaboration and mutual exchange of ideas among men of science from the most diverse domains of activity; in this connection we should like to remark on the theoretical and practical importance of the present conference with its high scientific tenor.

Summary /23

The problem of the noxious action of noise is becoming highly serious nowadays as a result of the extension of the radius of action of this noxa through the processes which characterize modern society: urbanization, motorization, industrialization.

From our data and those of other authors it can be inferred that there is a causal relationship between the degree of sound pollution and the state of health of the population from the standpoint of local effects (deafness, auditory fatigue, communication jamming) as well as general effects (increase in pathology through general morbidity).

In view of the seriousness of the situation, measures for controlling sound pollution and counteracting its noxious biologic effects appear as a strong necessity.

Alongside of the technological methods which play the main role in combating noise at its source, prophylactic programs play an important role in the fight against noise.

Medical programs are called upon to ensure efficient protection of those who are exposed to noise in those cases when control at the source through adequate technological measures is not yet possible.

Collaboration among experts from different domains is highly important for the victory over noise.

REFERENCES

1. Cadariu, G. and A. Ionescu, Atlasul principalelor surae de poluere sonora din M.B. [Atlas of principal sources of noise pollution in the town of Bucharest], arhiva Inst. Igiena, 1971. /22

2. Bugard, F., "The world of noise," L'usine nouvelle, Spring issue, 1965.

3. Ministry of Industria Chemn., Zgomote si vibratii [Noises and vibrations], Bucharest, 1969.

4. Cadariu, G. and A. Ionescu, "Biological significance of changes in the hearing threshold induced by the variability of the sound environment," Fiziol. Norm. si Patol. 5 (1973).

5. Rosen, S., "Epidemiology of hearing loss," Int. Audiol. (Leiden) 8/3, 260 (1969).

6. Cadariu, G., A. Ionescu et al., Studiul influentei zgomotului si vibratiilor asupra muncitorilor din industria constructiilor de masini [Study of the influence of noise and vibrations on workers of the machine-building industry], arhiva Inst. Igiena, 1972.

7. Zamfi, G. and D. Mocanu, "Sonic pollution and its influence on the organism," Igiena 9, 275 (1972).

8. Ward, D., "Proposed damage risk criteria for intermittent noise exposure," XV Congr. Int. Med. Trav., Vienna, 1966, p. 143.

9. Cadariu, G. and B. Barhad, Igiena muncii [Labor hygiene], Ed. Medicala, 1966, p. 170.

10. Pilat, Gavrilescu, Bolile profesionale [Occupational diseases], Ed. Medicala, 1966, p. 504.

11. Jansen, G., "Experimental study of the physiological action of noises," Rev. d'acoust. 20, 161 (1972).

12. Gratina, C., G. Cadariu, A. Ionescu et al., "Influence of noise on the cardiovascular apparatus," Fiziol. Norm. si Patol. 4, 357 (1970).

13. Anitescu, C. and G.H. Cadariu, "Effect of sound vibrations on aldolase and alkaline phosphatase," Arch. Mal. Prof. 3c/9, 505 (1969).

ACOUSTICS ON OIL WELL DERRICKS; NOISE-INDUCED HEARING LOSS AMONG OIL WELL WORKERS

D. Dahl, K. Dietzel, P. Hoff, and D. Kleinfeldt
HNO Clinic of the University of Rostock, GDR

In order to take prophylactic measures with respect to occupational diseases, we must have real and scientifically exact data on the particular disease and on the work area and must determine -- as early and as completely as possible -- which workers are endangered or injured in their occupational activities. This is just as important for each new work area, for each new technology and for each new production process and branch of industry. /25

Such a situation and task lies before us in GDR petroleum production, in which we so far have accumulated no occupational hygiene experience in work areas.

In terms of otology, we are particularly interested here in the effect of noise on the workers.

In the literature which has been available to us, reports on the damaging effects of noise occurring on oil derricks upon the health of oil well workers have been given in Lehnhardt and in Tsuiki, Sakamoto et al (1964) among others. The authors report that on a floating oil rig where the noise level alternates between 90-120 phons during work periods and 70-90 phons during breaks, the possibility exists for the development of a noise-induced hearing loss among oil well workers. Frequency-analysis studies have not been made, however.

What organizational and technical situation do we encounter on the well installations?

As they work on the derricks, the oil well workers are exposed to noise which is generated as the drill pipes are driven by noisy air-cooled diesel engines with 300-400 hp outputs. Five such engines are set up in each case in a roofed shed made of wooden or metal panels, covering an area of about 300 square meters. /26 The shed is open on one side and is connected directly with the derrick platform here. The five engines are in full operation during the actual drilling process; only when the drill pipes are changed are two engines shut down.

During a shift, six to eight workers work on a derrick: two machinists in the machinery shed, a shift foreman at the passage from the machinery shed to the derrick platform, and drilling crewmen and derrickmen on the derrick platform and directly on the derrick. The noise to which each worker is exposed is thus

a function of his work area and drops off as the distance between the place where he works and the source of the noise increases. A 20-minute break from the noise is provided in the middle of the 8-hour shift. To this are added short and irregular "noise breaks" when materiel is procured. After 14 days of work, a work break, and thus a relatively long noise break, is provided in the form of a 4-day holiday.

We have conducted noise measurements at the different work areas with a PSJ 201 precision pulsed sound level meter and the OF 101 octave filter.

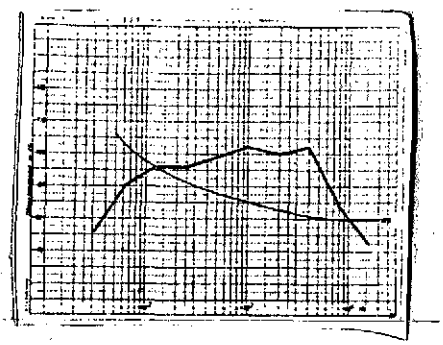


Fig. 1. Measurement location: center of machinery shed. Octave band analysis during drilling. Total noise level 106 dB (AI).

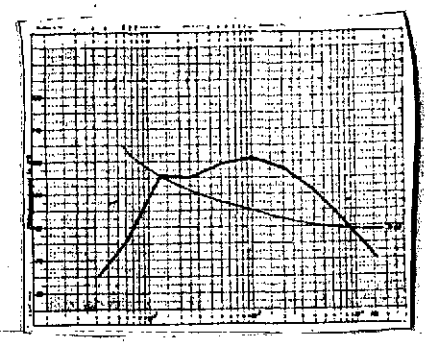


Fig. 2. Measurement location: between two diesel engines. Octave band analysis during drilling. Total noise level 105 dB (AI).

/27

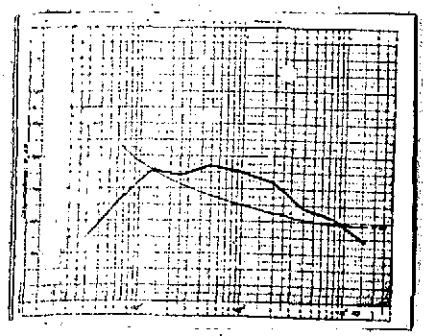


Fig. 3. Measurement location: shift foreman's work area. Octave band analysis during drilling. Total noise level 101 dB (AI).

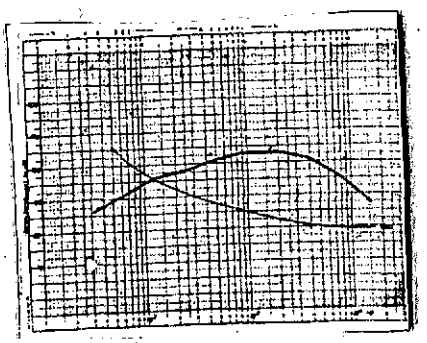


Fig. 4. Measurement location: center of machinery shed. Octave band analysis during drill-pipe change. Total noise level 110 dB (AI).

According to our studies, the noise generated on the derricks is a continuous noise without pulsed character, but upon which irregular compressed-air impulses are superimposed during pipe changes. The noise is measurable in the range from 31.6 to 10,000 Hz. In the frequency range from 125 to 8000 Hz, the noise level lies above the noise evaluation index of N 85 established for uninterrupted noise exposure during a workday by almost 20 dB at 1000 to 4000 Hz.

Thus according to the frequency analysis data, the possibility exists for damage to hearing by the noise to which oil well workers are exposed on the systems which are presently in operation.

We then examined 53 oil well workers otologically and audiometrically. The clinical histories of the workers contained no indications of inflammatory, severe, infectional/toxic or mechanical/traumatic hearing disorders. Subjective complaints such as tinnitus or a sensation of deafness were indicated in only isolated cases. The otological/clinical findings were normal and inconspicuous in all cases.

The audiometric examinations were performed as follows: /28

1. prior to the shift, after 16 hours away from work,
2. after the shift,
3. after a 4-day holiday, prior to the shift.

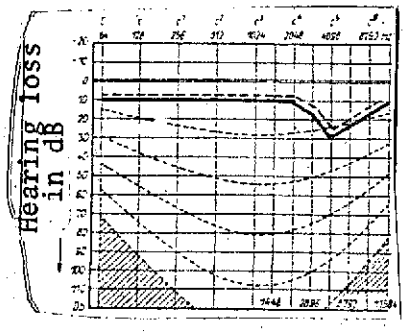
Evaluation

1. In 15 out of 53 of the subjects, hearing was normal. Mean age was 25 years, mean job time was 5 years. Work areas: four shift foremen, ten drilling crewmen, one derrickman.

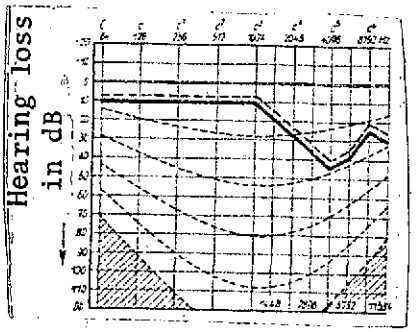
2. In 17 out of 53 there was an inner-ear hearing loss of 20 dB in the frequency range from 4000 to 6000 Hz. The mean age of this group was 26 years, job time 4 years. Work areas: four shift foremen, 11 drillers, one machinist, one derrickman.

3. In 21 out of 53 drilling workers, there was a pronounced or widened c^5 dip with a hearing loss of 20 to 50 dB. Mean age was 25 years, job time 5.8 years. Work areas: four shift foremen, nine drillers, four machinists, four derrickmen.

These hearing losses were primarily symmetrical. Only in 11 cases out of 53 was there a difference between sides, with a higher hearing loss on the left. This emphasis on the left side can be explained by the position of the worker relative to the



Group 2

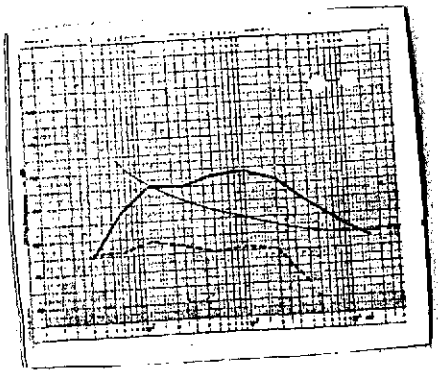


Group 3

noise source. In 13 out of 53 workers, a slight improvement in hearing, 7 dB, occurred after a 16-hour break from work, but without reaching the normal level. Otherwise no differences were /29
obtained between the audiograms taken at various times.

Thus demonstrable hearing impairment caused by work area noise exceeding the norm can be detected in a majority of oil well workers, according to our studies. If we compare the time which derrick workers spend working in noise with the time spent by other workers in noise of the same intensity and similar frequency composition, the smaller hearing loss experienced by derrick workers is striking, particularly as compared with that for metal workers. This fact can probably be explained by the frequent noise breaks and other spatial/acoustical conditions. Since the installations are also located out-of-doors, additional noise factors cannot have a potentiating action. We feel, nevertheless, that the work areas of oil-drilling workers must be declared high-noise work levels and detected damage to hearing be acknowledged as an occupational disease. This indicates the need for a suitable form of hearing protection which is portable in practical terms and the need for initial otological and audiometric examinations when workers are hired for oil drilling, as well as the corresponding check-ups. For the machinist, who is of course exposed to the greatest danger, we have set up a booth that separates the work area from the machinery area. The associated noise measurements are plotted in the figure below.

Ear-protector caps are best for the other workers, since /30
they already wear hard hats which can be combined well with ear-protector caps. Fiberglass wool does not have a sufficient muffling effect for the noise bands which were measured.



—— Measured in front of booth, total noise level 102 dB (AI)
--- Measured in the booth, total noise level 80 dB (AI)

Summary

The noise generated on derricks is a continuous type which sometimes considerably exceeds standard N 85. In 38 out of 53 drillers who had worked for an average of 5.5 years on the derricks, this noise had caused slight or moderate inner-ear damage. This study points up the need for hearing protection and check-ups. It supports the need for acknowledging detected hearing impairment as an occupational disease.

REFERENCES

1. GDR Standard TGL 10687.

2. Dieroff, H.-G., "Die Lärmschwerhörigkeit in der Industrie [Noise-induced hearing loss in industry], J.A. Barth Verlag, Leipzig, 1963.

3. Lehnhardt, E., "Occupational injury to the ear," Arch. Ohren Nasen Kehlkopfheilkunde 185, 11 (1965).

4. Tsuiki, T., S. Sakamoto, T. Honma, N. Numakura, J. Kon and H. Aizawa, Hirosaki Igaku 15, 734 (1964).

STUDY OF THE DISPERSION OF PURE-TONE HEARING THRESHOLDS

Eugen Teisanu and Emil Motas
Vitan Polyclinic, Bucharest

Investigation of pure-tone hearing thresholds constitutes /31
one of the principal hearing tests for clinical purposes, hearing examinations, labor protection, occupational orientation and selection, etc.

The different methods now in use yield results that differ more or less from one another. Even if the tonal hearing threshold is measured in a single individual with a precisely defined method and under as similar conditions as possible, differences can be observed between different measurements. It is obvious that these differences can be more readily disclosed with the aid of an audiometer and a method that measure small steps, for example 1 dB, than with a coarser apparatus and method that measure, for example, in steps of 5 dB.

Assuming that measurement technique and conditions have been specified, successive measurement results show deviations caused by fortuitous factors and can therefore be regarded as values for the selection of a normally distributed random variable, or one that approximates a normal distribution. This hypothesis of normalcy is justified on the analogy of many biological variables.

It is known from statistical theory that a normal random /32
variable is nicely characterized by its mean and its variance. If the variance is small, the arithmetic mean of a small number of threshold measurements constitutes a good estimate of the true threshold mean. As the variance increases, this mean of a small number of measurements characterizes the true mean of the variable less and less nicely, and only precise knowledge of the mean as well as the variance can characterize the variable in a satisfactory manner. Knowing the mean μ and the variance σ^2 and confining ourselves to the interval $(\mu - 3\sigma, \mu + 3\sigma)$, the number of cases that fall outside of this interval is negligible. The extremities of this interval constitute from the audiologic point of view the highest and the lowest threshold, respectively.

Knowing the variance is of practical interest not only for more accurate measurement of hearing thresholds but also for interpretation of the results obtained. Thus, the magnitude of the variance, confirmed by other data, permits us to draw conclusions about the psychosensorial development of a child, emphasizes the psychoneurotic component of a hypoacusia, orients the topognosis of lesions in diseases of the auditory apparatus, evaluates the degree of cooperation in a hearing examination, etc.

Interpretation of the organ of hearing as a simple energy transducer characterized by an equation like the Weber-Fechner law can no longer be regarded as more than a vague approximation, unsatisfactory for the practical purposes enumerated above. Threshold variation in time, on the other hand, which is caused by a number of psychoneurophysiological and pathological factors, finds a correct statistical reflection in threshold variance.

Customary in current audiologic practice is the representation of thresholds on a curve by a point or a number of decibels that stands for the result of a measurement or the mean of several measurements or the minimum of several measurements or other procedures, leaving the threshold variance aside. To a certain extent any great value of the variance is nevertheless taken into account whenever the examiner encounters great variations between at least two measurements on a single frequency, an irregular zig-zag curve for several frequencies, disagreement between tonal and vocal audiograms, etc. These methods of estimating the variance are not very precise and bring to light only relatively large variances. //33

In principle, the greater the accuracy desired in the determination of variance, the greater the number of measurements must be. In practice, the carrying out of a great number of measurements is inoperative or comes up against great difficulties. Besides the expenditure of time we must bear in mind that prolongation of the examination in itself alters the quantity to be measured.

In order to overcome these difficulties we worked out a procedure whose probabilistic mathematical model we reproduce below, together with a first experimental statistical study. This procedure consists in using for threshold measurement, in addition to an ordinary technique which approximates the mean of the thresholds for the given method, at least one more auxiliary method for the purpose of approximating the abscissa of the point of inflection of the threshold distribution density. Should two different auxiliary methods be used in addition to the usual method, one of these will approximate a smaller abscissa of the point of inflection than the mean and the other method will approximate a greater abscissa of the point of inflection than the mean. The first auxilary method is a facilitating method and the second method is a complicating method; they yield respectively smaller and larger values than the usual method. Using the simplifying method we presented the tonal stimuli alternately to both ears beginning with supraliminal intensities and descending gradually to the assumed threshold, and using the complicating technique we associated the pure tone as stimulus to be perceived monaurally at the threshold with a white noise with an intensity 10 dB above the threshold for this noise. /34

The mathematical justification for using at least two measurement methods with different results is to get a better approximation of the variance for the number of measurements effected. Let us designate by $T \in N(\mu, \sigma^2)$ a normally distributed random variable with mean μ and variance σ^2. Let $X \in N(\mu, \sigma^2)$ be the given random variable for the hearing threshold investigated by the ordinary method. Let $Y \in N(\mu_1, \sigma_1^2)$ be the given random variable for the hearing threshold investigated by a different technique (i.e., $X + C = Y$ where $C \in N(\mu_1 - \mu, \sigma_1^2 + \sigma^2)$). Let $Z \in N(\mu_2, \sigma_2^2)$ be the given random variable for the hearing threshold investigated by another different technique (i.e., $X + C_1 = Z$ where $C_1 \in N(\mu_2 - \mu, \sigma_2^2 + \sigma^2)$). We wish to determine C and C_1 (on an average) in such a manner that μ_1 and μ_2 will approximate as nicely as possible the abscissas of the points of inflection of the distribution density of X. That is to say

$$\mu_1 \leq \mu + \sigma \quad , \quad \mu_2 \geq \mu - \sigma \tag{1}$$

Taking into account the differences introduced, this amounts to

$$E(C) \leq \sigma \quad , \quad E(C_1) \leq \sigma \tag{2}$$

Note. $E(C)$ and $E(C_1)$ can be determined experimentally, which means satisfying relation (2) (the ideal situation is when we have an equality in (2)). Investigation of the tonal hearing threshold in an experimental group of 100 persons by the ordinary technique (represented by random variable X) yielded the following results: $X \in N(\mu, 29.18)$. Therefore the points of inflection have abscissas $\mu - 5.4$ and $\mu + 5.4$, respectively. The hearing threshold was investigated in the same group by a facilitating method and by a complicating method, resulting in /35

$$E(C) = 11.8, \quad E(C_1) = 4.5$$

It is obvious that in the case of the complicating method employed mean μ_1 does not satisfactorily approximate the corresponding abscissa of the point of inflection of X (because it exceeds it by far). By adjusting the method through reduction of the associated noise, however, it is possible to reduce the complication and find a satisfactory approximation. It is obvious that the adjusted method must be subjected to a new experimental statistical verification.

In the case of the facilitating method the point $\mu = 4.5$ constitutes a good approximation of the abscissa of the second point of inflection of X, which is $\mu = 5.4$. The difference of 0.9 dB can be neglected or the measurement results can be rounded off or, if greater accuracy is sought, these 0.9 dB can be calculated incident to determination of the abscissa of the point of inflection.

Greater accuracy can be obtained by adjusting the facilitating method; this, however, entails a new experimental statistical verification. The method should be adjusted in the direction of greater facilitation.

Conclusions

/36

1. Determination of threshold variance is useful in audiologic investigations but is in practice difficult to achieve with sufficient accuracy.

2. In order to facilitate their determination and/or increase the precision of this determination, a measurement procedure using at least two methods may be useful, which is demonstrated on the example of a probabilistic mathematical model.

3. For this purpose two auxiliary methods proposed by the authors may be useful, which is verified by an experimental statistical study.

Summary

/37

Determination of threshold variance can be effected by means of a sufficient number of measurements, which is inoperative in current practice.

To correct for inaccuracy due to the small number of measurements we worked out a method of approximation of tonal threshold variance through the approximation of the threshold distribution densities. This is accomplished by means of at least two different methods. One of them approximates the arithmetic mean of the thresholds, which is a common method of monaural liminal tonal audiometry.

Other methods approximate one or both points of inflection of the threshold distribution density. The methods of this kind that we used are based on alternate binaural presentation of tones or on monaural association of a pure tone with white noise.

• THE STATE OF HEARING AND VESTIBULAR ORGAN AMONG PERSONS SERVING ULTRASONIC DEFECTOSCOPES **

▲ Irena Ratajska, Wojciech Skrzypczak

■ CENTRAL RESEARCH CENTER OF THE RAILWAY HEALTH SERVICE
POLAND - WARSAW

The influence of ultrasounds on human organism has been investigated many times particulary by active application of ultrasounds on an industrial scale. They prove that ultrasounds have an influence first of all on the nervous system which controls the functions of many organs in the organism and this way it can have an influence on their state.

The subject of our work is the investigation of the state of hearing and vestibular organ among operators of ultrasonic defectoscopes used by the railways to test the state of rails i.e. by passive use of ultrasounds.

The ultrasonic waves / o, 685 mm of length / in exploited defectoscopes, because of their structure, are effectively attenuated by air. Considering this their influence on the defectoscope operator has been completely neglected. According to some authors/ Greguss, M czewski i inn. / the main danger for the men serving defectoskopes is the magnetic field of high frequency currents. The influence of the elektromagnetic field can be in our case left out because of a small power used in the device / o, 25 W /.

In the types of defectoscopes under exploitation the de-

** The text of all articles written in English has been reproduced from the original book.

...t in the tested material is magnified by an optical and ... acoustic indicator. The acoustic signal reaches the operator through earphones placed on his ears.

Methodics of work

The test of the level of acoustic signal emitted through the phones to the ears of the operators was done with Bruel-Kjaer apparature. Audiometric threshold curves were made with an audiometer complex in silent room. The recording of nystagmus was carried out by an electronic controlled chair and by an electronystagmograph Tönnies production. In this last test an spontaneous and positional nystagmus was observed in the sitting and supine position, on the left and right side and in Rôdé's position.

The results of the hearing and vestibular organ state of the defectoscope operators were compared with corresponding results of tests of a 70 person's control group.

Own investigations

The measurement of the acoustic signal intensity emitted through the phones showed that it is of 116,5 dB_A, and is contained in an octave of middle frequency 500 Hz. During 8 hours of work-... 400 of such signals are released as the result of passing defectoscope through the rail connections. Signals released by the presence of rail damage should be added to this number. These signals are acting as a stroke-they appear and disappear suddenly. They may have a injurious effect on the organ of hearing.

There were examined all persons serving ultrasonic defectoscopes used in the railways / number of 107 persons /. Tabl. 1 shows the state of hearing of the persons tested according to

40

Reproduced from best available copy.

[illegible] of	Age of persons tested				Ears together
	20–30	31–40	41–	51–60	
[illegible]	77	33	10	1	121
[illegible] to 35 dB	28	8	5	3	42
[illegible] over 35 dB	15	4	2	–	19
[illegible] curve [illegible] up to 35 dB	6	2	1	2	11
[illegible] curve run up over 35 dB	2	1	2	2	7
[illegible] of sound transmission	10	–	2	–	12
[illegible]	138	48	22	8	214

Tabl. 1 The state of hearing according to the age of persons tested.

From the data in the table it is evident that among 214 ears in 28 cases / 24% / there has been observed a serious acoustic trauma. It was almost always bilateral.

The result of elektronystagmographic tests are presented in tabl. 2 and 3.

Age	Number of persons	Number of persons with Ny	Number of persons with Ny in 2–5 position			
			2	3	4	5
20–30	68	28 /41,2%/	8	11	4	5
31–40	24	10/ 41,6%/	2	1	4	3
41–50	11	5 /45,4%/	1	–	–	4
51–60	4	2 /50%/	1	1	–	–
Total	107	45 /42%/	12	13	8	12

Tabl. 2 Results of elektronystagmographic tests according to the age of tested persons.

The data in table 2 show that among 107 persons the nystagmus at least in two positions appeared among

45 persons ; i.e. in 42%. It is significant that in the majority of persons it appeared in 3, 4 or5positions of the body / 31% /.

It is also observed that the percentage of nystagmus increases with the age of persons tested.

Years of work	Number of persons	Number of persons with Ny	
		in 2 positions	in 3-5 posi.
up to year	23	4 /7,4%/	7 /30,4%/
1 to 3 years	30	4 /13,4%/	11 /36,6%/
3 to 5 years	15	2 /13,4%/	1 / 6,6%/
5 to 10 years	39	2 / 3,4%/	14 /36%/
Total	107	12 /11,2%/	33 /30,8%/

Tabl. 3 Results of electronystagmographic tests according to the period of work of persons tested.

Table 3 shows a certain abnormality between nystagmus and the period of work. The results of tests of persons working from 3 to 5 years, proved to be abnormal. The percentage of nystagmus among those persons is only 20% compared with 39 to 50% for the group of persons having an other period of time.

Comments

The results of the investigations indicate that the state of hearing and vestibular organ among the ultrasonic defectoscope operators is affected by the acoustic stroke impulse transmitted to the ears through the phones / 116,5 dB_A /. The occurance of acoustic trauma is twice more frequent / 24% / than in control group, where it occurs in 11%.

The vestibular organ seems to be more exposed. It is

42

Reproduced from best available copy.

...ic.ted by nystagmus occuring in this case in a larger number ...f positions than in a norm. In the control group nystagmus in ... to 5 positions occurs in 15%, whereas among defectoscope opra... tors it occurs almost in 31%.

The injury of acoustic impulse to the state of hearing is explained by stroke character of the impulse signals. The influence of the acoustic signal on the vestibular organ is explained by affecting the saccule. Many authors emphasize / Fournier, Goua and others / that especially sounds in octave band of middle frequency 500 Hz high degree have a impulse effect on the vestibular saccule.

Such an acoustic characteristic has a signal of very high power emitted through phones to the operator's ear.

43

Summary

Audimetric tests of hearing and electronystagmographic tests of equilibrum among 107 persons serving ultrasonic defectoscopes (connected with the control of Polish State Railways) showed :

- a much higher percentage of hearing impairment from normal (24% to 11%) ;
- nystagmus occuring almost two times as frequently as normal (31% to 15%);
- the occurance of nystagmus grows stronger with the age. A smaller correlation is observed compaired with years of work.

The tests show that in impairment of the hearing and vestibuler organ may be caused by stroke character of the acoustic signals.

ADAPTATION PROBLEMS OF WOMEN TEXTILE WORKERS

Stefan Girbea and Mihal Negulescu
Otorhinolaryngological Clinic, Coltea, Romania

The last 10 years have witnessed the publication of ever more studies dealing with occupational diseases in different enterprises. Thus, the complexity of the noxae (silicon dust) with a high content of free silicon, great variations in temperature, dust, relative humidity, speed of air currents, intensity of noise and vibrations, gases like carbon dioxide, etc.) in mines and in the most diverse industrial enterprises can give rise to acute and chronic ORL affections such as rhinosinusitis, pharyngolaryngitis, catarrh of the auditory tube, otitis, atrophy of the nasal mucosa with perforated septum and pulmonary affections such as silicosis, pulmonary fibrosis, etc. /45

Besides these affections we often encounter lesions of the auditory organ in workers exposed to noise with an intensity in excess of 90 dB.

Thus, in the mining sector noise and vibrations are produced by pneumatic drills and explosions; in metallurgical plants for mining equipment, besides noise and vibrations, dust is produced, as well as variations in temperature and carbon dioxide; in the metallurgical sector for drilling noise is produced by pneumatic hammers; and in the textile industry by weaving looms, to which must be added cotton lint and humidity.

That is why the physician can never remain aloof from production, but must be at the work spaces to collaborate with technicians with a view to the prophylaxis of occupational diseases.

With the expansion of industrialization in our country this problem has grown vertiginously through the continual apparition of new enterprises, each of which has its own noxae harmful to the human organism.

Thus, we decided to study the adaptability of the women workers in the new "Dunareana" textile mill in Giurgiu, to a noxa that was new to them: noise and vibration. /46

Of the newly-hired young workers (17-25 years), some had attended a trade school for 6 months to 2 years before being hired while others were receiving on-the-job training.

At the obligatory prehiring ORL examination those with affections conforming to the ready reckoner were not hired for work in weaving departments, but in other work spaces.

Investigated were 268 workers, of whom 103 had attended a trade school for 2 years or worked for 6 months in other textile mills while the other group of 165 newly-hired girls had no experience in a noisy environment.

At the hiring examination of the first group of 103 workers with experience in a noisy environment, it was found that of the 57 with 2 years of school, 28 were healthy and 29 had hearing disorders, including general disorders, while of the other 46 with 6 months of school, 23 were healthy and 23 had hypoacusias.

Of the 165 newly-hired girls examined after 3 months, there were 45 cases of hypoacusia and after 6 months, 68 cases. The rest of the cases did not present themselves regularly for check-ups.

In addition to the general examination all acousticovestibular tests, including the audiometric examination, were carried out.

Thus, after the newly-hired girls had worked in the noisy environment for 3-6 months, examination before the start of work disclosed no audiometric changes. At the end of work we found a loss of 10-15 dB at frequencies of 1-2000 and of 20 dB at frequencies of 4000 and higher, as well as slight vestibular and functional disorders (headaches, palpitations, slight trembling of the extremities, irascibility and even behavior disorders).

In girls with a length of service of 6 months we found a loss of 15-20 dB around a frequency of 4096.

In girls with a length of service of over 2 years we found a maximum drop of 30-40 dB and an average drop of 15-25 dB at high frequencies and no change at low frequencies. General disorders were absent.

The noisy environment had an intensity of more than 85 dB.

In general, the young girls suffered at the start of work from the sound noxa, showing behavior disorders as well. /47

The loss in decibels increases with the length of service, the intensity of the noise, the sensitivity of the auditory apparatus and the degree of concentration of attention in daily activity.

The audiometric differences between the start and the end of work, as well as the return to normal through rest, testify to a process of adaptation to the acoustic noxa.

Repeated sound excitation and sound excitation that builds up for a long time show audiographic differences at the start and the end of work, with a new adaptation effected at a lower level than previous adaptations, depending on the harmfulness of the noise and the organism's reaction characteristics.

In general, prophylaxis dictates periodic examination at regular intervals in order to be able to ferret out the cases that show auricular weakness; mechanization of production with a view to a reduction in physical effort; improvement of the microclimate at the work space through collective measures like more efficient ventilation systems and systems for intercepting noxae, as well as individual measures like protective clothing, earplugs, protective food, vitamins, fortifiers.

In view of the multiple factors existing in the enterprise in which we carried out our study, the prevention of occupational diseases calls for the following: revision of the departments with noise above the permissible norm; disclosure of the vibration level and keeping track of the vibrations; utilization of antinoise materials and construction of absorbing walls; setting up of quiet rooms for rest periods; ferreting out of vestibular disorders incident to periodic examinations for the prevention of labor accidents; regular wearing of earplugs and surveillance of their wearing by effective action on the part of the labor protection service.

Summary

/49

In the "Dunareana" textile mill of Giurgiu we analyzed the different aspects of the adaptability of women workers to a noxa that was new to them, namely, noise and vibrations.

Of the 268 workers examined, 103 had attended trade school for 2 years or worked 6 months in other textile mills (group 1) while 165 had no training or previous experience in a noisy environment (group 2).

Group 1 comprised 28 healthy workers and 29 with hearing disorders. Group 2, which was observed at regular intervals ranging from 6 months to 2 years, manifested different degrees of hypoacusia as a function of age, extent of exposure to noise and sensitivity of the auditory apparatus. These hypoacusias were accompanied by moderate general disorders.

REFERENCES

1. Benettato, Fiziologie normala si patologica, No. (1962) [sic].
2. Benettato, Studii si cercetari fiziologice (4) (1962).
3. Codreanu et al., "The mechanism of auditory reception," Rev. ORL 3 (1963).
4. Costinescu et al., "Occupational hypoacusia in textile industry workers," Rev. ORL.
5. Dociu-Miclescu, "Vestibular disorders through sound trauma," Rev. ORL 2 (1962).
6. Girbea-Nigulescu, "Acousticovestibular disorders in a shipyard," 3 conf. pentru combaterea sgomotului si vibratiilor [3rd Conference on Combating Noise and Vibrations], Bucharest, 1969.
7. Grumazescu, Sgomotul si combaterea lui [Noise and how to fight it], Ed. Teh., 1956.
8. Sager: Studii de cercetari neurologice [Neurological research] [sic].
9. Racoveanu-Anghelide, Rev. ORL 2 (1962).
10. Rogevin, "Stress and psychological disorders," An. Rom.-Sov. 4 (1963).
11. Teodorescu et al., "The adaptation and rest factor in the appearance of occupational deafness," Rev. ORL 2 (1965).

INDIVIDUAL DIFFERENCES AND THE SOUND ENVIRONMENT IN OCCUPATIONAL ACOUSTIC TRAUMATISM

E. Teodorescu, E. Stratulat, and I. Cornea
ORL Clinic, M.T. Hospital, Iasi

The growing medicosocial importance of deafness through occupational noise has inspired a host of studies dealing with all aspects of the problem. At the same time, the irreversibility of occupational deafness has caused the accent to be shifted to its prevention. /51

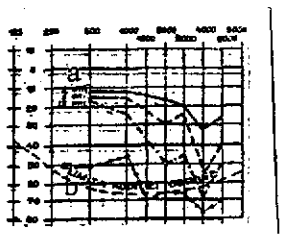
In this connection, however, attempts to increase the resistance of the auditory structures in the presence of noise by administering protective medication has proved to be quite inadequate for coping with the aggressivity of industrial noise [11].

Although auditory rest is categorically effective in abolishing auditory fatigue, it has not yet been legitimated as a preventive measure against deafness through occupational noise because the application of such measures to human biology [10] by systematizing for every noisy job environment the duration and rhythm of alternation of work periods and compensatory auditory rest entails many technological, organizational and economic difficulties.

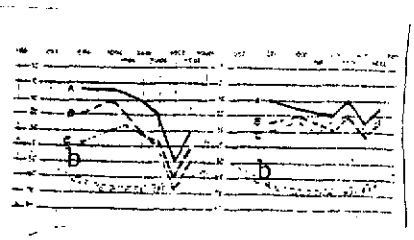
The selection of workers on the basis of individual differences in sensitivity to noise has proved to be practically ineffective in the absence of valid, time-honored criteria for the detection of this sensitivity [2, 4, 6].

In our 10 years (1963-1972) of research on adaptation and auditory fatigue through noise in a group of 14 control subjects, we obtained experimental verification of changes caused by stimulation with pure tones of 500 and 4000 Hz and with white noise, the duration of exposure to industrial noise being variable. /52

These experimental studies were supplemented with audiometric investigation of 112 workers with 1-20 years of service in the same noisy environment. The audiometric curves disclosed a hearing deficiency in keeping with length of service for 72% (audio. No. 1) but not for the other 28% (audio No. 2).



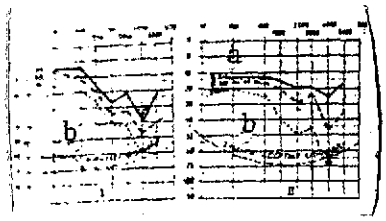
No. 1.



No. 2.

Key: a. Years; b. limit of osseous hearing.

Comparison of the curves for exposure of the control group to industrial noise for 30, 60 and 90 minutes with the average losses observed in workers with 2, 5 and 10 years of service in a noisy environment revealed noteworthy similarities. The curves for the controls exposed to 30 minutes of industrial noise overlap by a -10 dB characteristic, the definitive hearing losses of the group of workers with 12 years of service in noise and by a +10 dB characteristic, those of the group with 4-5 years of service (audio. No.3).

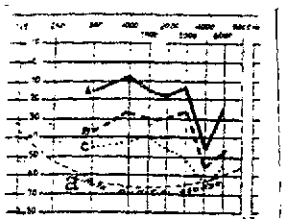


No. 3.

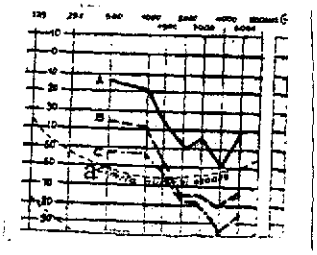
Key: a. Years
b. Limit of osseous hearing

Interpreting the results of these comparisons we can conclude that the mean temporary changes in hearing of the control group exposed to 30 minutes of noise would correspond to the permanent hearing deficiency caused by 3 years of work in noise. /53

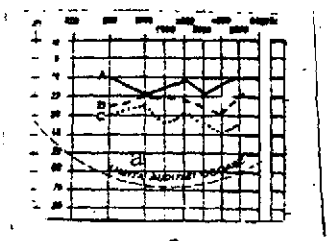
Analysis of the dynamics of the individual curves of a group of 74 workers after 4 years and of 36 of these whom we could follow up for 6 years evinced a parallelism between the curves obtained prior to stimulation and those obtained after 5 hours of activity, as well as with those obtained after another 4 and 6 years of work in the same noise environment (audio. Nos. 4, 5, 6).



No. 4.



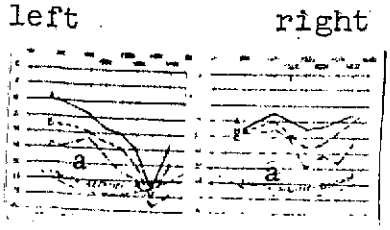
No. 5.



No. 6.

General key: a. Limit of osseous hearing.

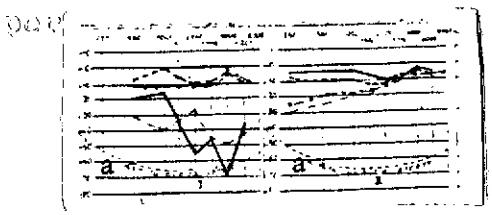
The same parallelism was observed in the case of the homolateral curves [12] of those persons with interauricular auditory inequalities, demonstrating the constant character of the individual and monaural auditory reaction in the absence of an unforseeable accident and under unchanged conditions of the occupational environment (audio. No. 7).



No. 7.

Key: a. Limit of osseous hearing

Reproduced from best available copy.



No. 8.

Key: a. Limit of osseous hearing

Sound environment conditions crop up as a fundamental factor in determining the character of the hearing deficiency caused by noise.

Eloquent in this connection /54 is the different character of the audiometric curves obtained in 1964 for a subject of the control group who was exposed to industrial noise (audio. No. 8), as compared with the auditory periods observed in 1972 in the same subject (a stomatologist) under occupational noise conditions caused by a dental bur.

This body of findings enjoined us to draw the following conclusions:

1. Determination of the auditory reaction to noise is conditioned by many factors, both general and local;

2. Individual differences, which Ward [14], citing Folsbruck, considers to be of a congenital nature, are actually an expression of the proper constitutional background. This constitutional background is determined by hereditary biological properties that are permanently shaped by the whole gamut of local, regional or general accidents (traumatic, toxic, infectious, circulatory, metabolic and reactional) that crop up in the course of life, accentuating or attenuating inherited individual differences in auditory acuity and reaction to sonic stress.

3. Individual differences in auditory susceptibility to noise, as the personal expression of the phenomena of adaptation /55 to acoustic excitation and of auditory fatigue, can be discerned in nearly all proposed tests.

4. The results obtained with these tests have an incontestable experimental value. Inasmuch as these results are conditioned by the characteristics of the particular test employed, their value is limited to the proper conditions of this test and are therefore inadequate for estimation of the tardive hearing deficiency that is caused by occupational noise.

Analysis of the different methods of testing susceptibility to deafness through occupational noise that are based on utilization of pure tones, white noise or recorded industrial noise brings out their common error of transposing the results obtained under the artificial conditions of the experiment to the infinite variety of conditions of the aggregate that the "sound environment" peculiar to every noisy work environment constitutes [13].

As a practical consequence of these conclusions, we eliminated from our subsequent studies [8, 9] the deformation of the auditory reactions that are elicited by the artifice of pure tones, as well as those consequent upon the superposition of different white noise frequencies. Using industrial noise under production conditions as a test for individual sensitivity to noise, we respected the highly diversified characteristics of the aggregate that the "sound environment" constitutes, which is even changed in the course of testing with "recorded" industrial noise [7].

Subsequently, testing with industrial noise appeared in the studies of Ward (1965) [14], Apostolov (1967) [1] and Devèze (1971) [3], who used the test under different conditions from ours.

Basing itself on an interpretation that can be assimilated to our conception, the German Engineering Association introduced (1971) [5] as the standard for estimating the harmfulness of factory noise the mean value of the changes in hearing that industrial noise induced in a control group. /56

Thus, the value of the "exposure" test for occupational noise that we proposed in 1964 seems to be confirmed by subsequent data in the literature.

Thus, the value and character of the noise-induced hearing deficiency appears to be conditioned by two fundamental factors:

-- individual peculiarities of the auditory apparatus and

-- the characteristics proper to each noise situation that goes to make up the sound environment.

It ensues from this double conditioning of deafness through noise that testing auditory susceptibility to noise with a view to estimating tardive hearing deficiency is only possible by means of methods that take into consideration the individual peculiarities of the auditory organ as well as the characteristics of noise as an aggressive factor in the total sound environment of which it is a part.

In view of the present state of the art, we believe that the "exposure" test for occupational noise constitutes a criterion of incontestable practical value in the prevention of deafness through occupational noise.

Summary

/58

On the basis of experimental research on guinea pigs, experimental observation of volunteers and comparative audiometric investigation of a group of workers in the course of 6 years, the authors outline the complexity of the factor constituted by individual differences in susceptibility to acoustic traumatism and bring out the importance of the factor constituted by the "sound environment" in conditioning the characteristics of the resultant hearing deficiency.

Stressing the topical importance of preventing chronic acoustic traumatism, they prove the following:

-- the necessity of basing tests for the estimation of the hearing deficiency that occupational noise probably induces in time on the two background factors constituted by individual differences and the sound environment, respectively;

-- the time-honored practical value of the "exposure" test they proposed in 1964.

REFERENCES /56

1. Apostolov, C., Oto-Rhino-Laring. (Sofia) 4/2, 49-59 (1967).

2. Constantinescu, F. and S. Segal, La III-e Conference sur la lutte contre le bruit et les vibrations [The 3rd Conference on the Fight against Noise and Vibrations], Vol. 3, Bucharest, 1969, pp. 29-35.

3. Devèze, G. Arch. Mall. Profess. 32/10-11, 671-673 (1971).

4. von Dishoech, R.A., Acta Oto-Rhino-Laryng. Belg. 3, 213 (1960). /57

5. Jansen, G., Acta Oto-Rhino-Laryng. Belg. 1-2, 203-210 (1971).

6. Ledoux, A. and B. Depaepe, Acta Oto-Rhino-Laryng. Belg. 4, 332 (1961).

7. Ledoux, A., Acta Oto-Rhino-Laryng. Belg. 8, 249 (1971).

8. Teodorescu, L. et al., Consf. "Adaptarea organismului la condi-tiile de munci din transportul feroviar [The "Adaptation of the Organsim to Railroad Working Conditions" Conference], Cluj, 1964.

9. Teodorescu, L., M. Leivovici, E. Stratulat, I. Cornea, Ort. Mine-can, Oto-Rino-Laringologie (Bucharest) X/2, 109-121 (1965).

10. Teodorescu, L., M. Leibovici, E. Stratulat, I. Cornea, and R. Costinescu, La III-e Conference sur la lutte contre le bruit et les vibrations [The 3rd Conference on the Fight against Noise and Vibrations], Vol. 3, Bucharest, 1969, pp. 129-135.

11. Teodorescu, L., M. Leibovici, E. Stratulat, I. Cornea, and R. Costinescu, Oto-Rino-Laringologie (Bucharest) 1, 9-24 (1970).

12. Teodorescu, L.,E. Stratulat, and I. Cornea, Audiology (Basel) 11 (Supplement), 48-49 (1972).

13. Teodorescu, L., E. Stratulat, I. Cornea, and P. Velea, The "Problems of Occupational Pathology in Otorhinolaryngology" Conference, Baia Mare, November 4, 1972.

14. Ward Dixon, W., Journal of occupational medicine (Minneapolis), 595-612 (1965).

SOME ASPECTS OF THE RELATIONSHIP BETWEEN TEMPORARY AND PERMANENT HEARING THRESHOLD SHIFTS IN THE EVOLUTION OF OCCUPATIONAL HYPOACUSIA

G. Mihail, D. Mocanu, G. Branisteanu, M. Vasilov, and E. Teodorescu
Iasi Institute of Public Health and Medical Research, Romania

Investigation of auditory fatigue as a limiting case between physiological and pathological acoustics, which is associated with the names of Peyser, Luscher and Wislucki in the USA and Caussé and Chavasse in France [1, 3], has been the object of many experimental studies since as early as 1940. /59

In order to define auditory fatigue such terms have been used as "temporary deafness," "temporary hearing loss" and, more recently, "temporary threshold shift" or TTS, by which latter term is meant a temporary drop in auditory sensitivity owing to noise exposure, a drop which reverts to the initial level in a few minutes, hours or days after exposure ceases [1, 4, 5, 9].

The chronic action of noise leads to permanent and irreversible drops in auditory sensitivity, i.e., the "permanent threshold shift" or PTS [2].

Attempts have been made to establish a relationship between PTS and TTS on the assumption that noise which cannot produce TTS, cannot produce PTS, either. Moreover, TTS values have been invested with a predictive value and a value as a test for individual susceptibility to noise (Peyser, Harris, Ward [7, 8, 10]).

Sataloff [6] is skeptical about the predictive value of TTS for the evolution and gravity of PTS because he arrives at contradictory results for the relationship between TTS and PTS. In view of the great individual differences and, especially, the diversity of occupational exposures (intensity, spectral composition, duration of the noise, etc.), Ward himself subsequently changed his mind about the exactness of this relationship.

Devèze asserts that the predictive value of TTS, so important for labor medicine, could probably be elucidated through studies in depth involving comparison of initial TTS values incident to hiring with the evolution of PTS once it has set in after years of daily occupational exposure [1]. /60

We studied the effects of industrial noise on the auditory sensitivity of workers from two different types of enterprises and the relationship between TTS and PTS as a function of length of exposure to noise and concomitant noxae for the purpose of checking

the prophylactic value of audiometric examinations on the job and elucidating the variations in the threshold after 16 hours of auditory rest.

Methods and Materials

Within the framework of audiometric screening we examined 567 persons exposed to occupational noise in two industrial enterprises: a group of 211 workers from a metallurgical plant with an occupational exposure ranging from 0 to 10 years and an average age of 32.8 years and a group of 356 persons from a weaving mill, for the most part women, with an average age of 33.1 years and a length of service ranging from 0 to 20 years.

The audiometric examination for air and osseous conduction was effected with the aid of a portable audiometer using tonal audiometry after approximately 4 hours of exposure to occupational noise.

After sorting and eliminating subjects with normal hearing (up to 30 dB for all frequencies between 125 and 10,000 Hz), which amounted to 23% at the metallurgical plant and 22.6% at the weaving mill, and subjects with pathological antecedents, which amounted to 12% at the metallurgical plant and 15.2% at the weaving mill, we reexamined from among those with drops in the hearing threshold greater than 30 dB, which were certainly of an occupational nature, amounting to 64% at the metallurgical plant and 62.1% at the weaving mill, a group of 86 workers after 14-16 hours of auditory rest (before returning to their shift).

The level of the drops in auditory sensitivity after this rest period was regarded as the limiting factor for recovery during this time period of at most 16 hours representing the real auditory capacity of the subjects because after they have returned to their shift, the noise effect will induce an additional loss in /61
the hearing threshold of the rest period down to the previously determined TTS [5].

Comparison of the mean values of the temporary and permanent threshold shifts in sensitivity yielded the following results:

Results and Discussion

Taking into consideration the mean values of the permanent losses in sensitivity for osseous conduction alone, which expresses the sensitivity of the auditory nerve and the mean values of the temporary drops in sensitivity for the entire textile plant group, the results are as follows:

TABLE 1.

Mean PTS values in dB

Hz	250	500	1000	1500	2000	3000	4000	6000	8000	10000
Right ear	8	7.5	18	21.5	25	32.5	39	29	19.4	11.4
Left ear	8.2	6.5	19	27.3	27.3	35.8	38.3	30.7	21.4	13

Mean TTS values in dB

Right ear	16.5	13.8	26.2	34.2	33.7	41.3	46.5	38.4	32.2	14.6
Left ear	15.1	13.8	28	32	32.9	42.2	49.8	38	42.2	13

It can be observed that the differences between the two mean thresholds of the TTS and PTS range from 5 to 12 dB, values close to those mentioned in the literature (10-12 dB).

TABLE 2. MEAN TTS AND PTS CHANGES IN dB.

Hz	250	500	1000	1500	2000	3000	4000	6000	8000	10000
Right ear	8.75	5.87	9.47	11.4	10.57	9.07	8.07	10.4	12.65	5.5
Left ear	7.37	7.3	8.97	5.1	5.82	8.42	12	7.92	10.75	3.7

Analysis in terms of groups characterized by length of noise exposure discloses the following:

a) The temporary shifts from initial values for the group with 0-5 years of occupational exposure are comparatively much greater than for the entire group and for the other groups. /62

b) The difference between TTS and PTS is smaller for the group with 6-10 years of exposure and less for the group with 11-15 years of exposure, the TTS and PTS curves being very close.

These points can be explained as follows:

-- In the first place, the harmfulness of noise has been clearly demonstrated;

-- The more pronounced difference between PTS and TTS in the group with 0-5 years of service is relevant for the phenomenon of auditory fatigue and the adaptation period fluctuations specific to the group;

-- Preservation of the capacity to return to initial values has been demonstrated even at the 4000 Hz frequency level, although a general reduction in the threshold already begins to show;

-- In the group with 6-10 years of exposure the values return to a definitive threshold above 40 dB, with a loss maximum at 4000 Hz and a minimal difference between TTS and PTS at this level;

-- In the group with 11-15 years of service there is a greater drop in the possibility of returning to normalcy during rest, and TTS and PTS tend to merge into each other. We can consider the evolution of hypoacusia, though progressive, to be slower. This aspect of the curves confirms the assertion that "in order to induce a further hearing loss, the intensity of the sound stimulus must be the greater, the more advanced the loss in sensitivity." Now a trait of weaving mill noise is its continuous character even at a relatively constant level of 102-103 dB, which is exceeded in the 500-1000 Hz range.

Comparison of the two homogeneous groups with 6-10 years of occupational exposure from the weaving mill and the metallurgical plant brings to light smaller mean differences between TTS and PTS for the group from the metallurgical plant and greater shifts in the intermediate frequency range.

TABLE 3. /63

Mean TTS values in dB

Hz	[illegible]	500	1000	1500	2000	3000	4000	6000	8000	10[illegible]
Right ear	12	20.2	19.5	27.2	22.2	41.8	47.9	36.5	35.3	22,9
Left ear	11.3	8.6	23.4	32.0	25	29	45	36,5	32.5	25.[illegible]

Mean PTS values in dB

Right ear	15.6	27.2	21.1	24.5	19	36.8	42.4	30	24.5	17.9
Left ear	18.4	16.3	24.3	28.8	21.3	35.9	40.0	31.5	24.0	11.[illegible]

Reproduced from best available copy.

This aspect suggests a more rapid evolution of hearing losses in this group, which can be attributed, with a certain degree of probability, to the unfavorable influence of some concomitant noxae, from which the presence of CO cannot be excluded.

We might also invoke the higher noise level at the metallurgical plant, which reaches maximum intensities of 102-108 and even 114 dB during the execution of some operations; the intermittent character of these maximums against the factory's background noise, however, permits a partial recovery of hearing. Ascription of these effects to a different susceptibility between the sexes, the two groups not being homogeneous from this point of view, is unwarranted since this point has not yet been elucidated.

Conclusions

Relevant are the influence of auditory fatigue due to the action of daily exposures to noise above 95 dB and the role of temporary drops in hearing and of daily threshold fluctuations in the mechanism underlying permanent hearing losses.

Even if some reservations still exist about the exactness of the predictive value of TTS for the gravity of the subsequent evolution of PTS, this in no way diminishes the prophylactic importance of serial audiometric examinations of workers in noisy environments.

Inasmuch as it is difficult, from the organizational point of view, to give serial examinations after 16 hours of auditory rest, TTS determinations carried out for the purpose of preliminary sorting of occupational hypoacusias and re-examining them after auditory rest can constitute a current research method in initiating systematic tracking of hypoacusia evolution. /64

Although the idea has been gaining ground of late that the old criteria for estimating occupational hypoacusias ought to be reconsidered only on the basis of shifts for the 500-1000 and 2000 Hz frequency zone, which can cause social annoyance in conversation, we on the contrary consider that advance determination of temporary or permanent hearing threshold shifts that start at high frequencies (usually at 4000 Hz) before extending to intermediate frequencies, is of distinctly greater prophylactic and ethical value.

The fact that it may take the worker exposed to noise a while to become aware of hearing losses at high frequencies does not excuse us from taking all protective and preventive measures. It should be obvious that a man's reactions to signals connected with the productive process can be modified even by temporary hearing losses, so that it can affect his working capacity negatively and become a cause of accidents on the job.

Summary /66

The results of audiometric examination of workers with 0-15 years of exposure to noise of about 102 dB have revealed during the development of hypoacusia different aspects of the relationship between the temporary hearing threshold and permanent threshold shifts.

The level found after 16 hours of auditory rest, which is the period between shifts that affords the only opportunity for the threshold to return to optimal values before a new exposure to noise, was regarded as a permanent loss in sensitivity. Examination of the same persons after 4 hours of exposure to industrial noise yielded values for temporary hearing losses that, as compared with permanent reductions, differed for groups with different lengths of noise exposure. In general, it was found that the difference between the values of temporary and permanent hearing losses becomes attenuated as the length of noise exposure increases.

REFERENCES

1. Devèze, G., "Auditory fatigue," Arch. Mal. Prof. 32/10-11, 671 (1971).

2. Gallo, R. and A. Clorig, "Permanent threshold shift changes by noise exposure and aging," Amer. Ind. Hyg. Assoc. J. 25/3, 237-245 (1964).

3. Gulian, E., Zgomotul si activitatea umana [Noise and human activity], Ed. Acad. R.S.R., Bucharest, 1971.

4. Hermann, R.E., "Environmental noise hearing acuity and acceptance criteria," Arch. Environm. Health 18/5, 784 (1969).

5. Ouzts, J.W., "Industry temporary threshold shift (TTS) following exposure to high-intensity and variable peaked farm machinery noise," J. Audit. Res. 9/1, 64-70 (1969).

6. Sataloff, J., L. Vassalo, et al., "Temporary and permanent hearing losses: A ten years' follow-up," Arch. Environm. Health 10, 67-70 (1965).

7. Smith, P.E., Jr., "A test for susceptibility to noise-induced hearing loss," Amer. Ind. Hyg. Assoc. J. 30/3, 245-250 (1969).

8. Teodorescu, L., M. Leibovici et al., "Adaptation problems in auditory fatigue and occupational acoustic traumatism," Rev. ORL XV/1, 9-25 (1970).

9. Walker, J.G., "Temporary threshold shift from impulse noise," Ann. Occup. Hyg. 13/1, 43-49 (1970).

10. Ward, W.D., "Temporary threshold shift and damage risk criteria for intermittent noise exposure," J. Acoust. Soc. Amer. 48/2((II), 561 (1970).

MEDICAL ASPECTS OF AIRPORT NOISE

G. Clipici and G. Niculescu
Institute of Transportation Study and Research
Medicopsychology Section, Bucharest, Romania

Besides chemical pollution of air and water, industrial as well as civil sound pollution has today become one of the acute problems of modern society. /67

Among the many noise sources whose impact is growing, aeronautical transportation occupies one of the first places. Granted that noise was a specific feature of aviation since its very beginnings, when engines of the classical type had a power on the order of hundreds of hp, in this age of supersonic and large-tonnage aviation, it represents a harmful factor with serious repercussions not only on airport personnel but also on the population residing around airports.

Everybody knows that the principal source of aircraft noise is the operation of the engine and related assemblies.

The intensity and spectral distribution of the component sounds, however, differ within wide limits as a function of the type of engine. Thus, in the noise generated by the engines of classical aircraft (with piston and propeller), low frequencies predominate while in the noise generated by aircraft equipped with jet engines, the frequencies of the component sounds are, on the contrary, distributed in an approximately uniform manner throughout the range of the audible spectrum.

Amplitude measurements in the two types of aircraft presently employed by TAROM for international flights, the IL-18 (turboprop) and the BAC-11-1 (jet) have shown that, under similar conditions, the latter generate a clearly louder noise on the ground as well as in the air, in all phases of operation: taxiing, takeoff, flight and landing. At certain moments when, for a short period, the /68
engines are revving, noises far in excess of 100 dB have been recorded; thus, in the BAC-11-1 128 dB have been recorded and in the IL-18, 112 dB.

The effect of noise on the human organism is also determined by the fundamental parameters of the component sounds, namely, amplitude and frequency, which -- as we have just said -- have undergone important changes hand in hand with the development of aviation. Consequently, although much research has been done in this connection, beginning with the first decades of our century, it is now felt necessary to update the data on the harmfulness of noise under existing conditions.

It is known that if the subject is allowed to rest long enough for his auditory sensitivity to return to normal values before he is resubjected to the action of noise, occupational hypoacusia does not occur, even if auditory fatigue is systematically repeated. This explains a phenomenon noted by many authors, namely, that pilots generally do not suffer from hypoacusia in spite of being exposed to powerful noises: the relatively long period of time between flights permits the phenomenon of auditory fatigue to disappear completely until the next flight.

But the same thing cannot be said of airplane mechanics and other categories of airport service personnel who are subjected to noise for a prolonged period, with the result that the time allotted for rest of the auditory organ is less than that necessary for full recovery of auditory sensitivity. Many studies have brought to light that a great number of airplane mechanics suffer from different degrees of hypoacusia. Thus, according to Temkin, 53.7% of the mechanics examined showed a considerable drop in their capacity to distinguish whispered speech in strict correlation with length of service; audiometric studies carried out by the same author showed that the hearing threshold increased at all frequencies for 73-90% of the mechanics studied. It is interesting to note that, unlike other occupational categories, airplane mechanics are especially affected by the low frequencies of the audible spectrum. Similar conclusions were reached by Zaher who found morbid processes of the internal ear in 55% of the mechanics examined.

Our research, which was carried out on a group of 68 subjects /69
recruited from among the different occupational groups serving Otopeni Airport, consisted in determination of the hearing threshold for both ears with the aid of tonal audiometry, the results of which are shown in the accompanying table. It should be mentioned that, in the absence of a soundproof room, our determinations were carried out in a relatively quiet office placed at our disposal by the airport authorities.

The first thing to be noted from the table is the obvious differences between the two groups of airplane mechanics though their average age and their length of service are practically the same. Thus, the hearing thresholds for the mechanics who service the BAC-11-1 jets are higher at all frequencies investigated not only as compared with the mechanics who service the IL-18 turboprops, but also as compared with the other groups of occupations studied (with a few exceptions in the high frequency range). This fact, which tallies nicely with the noise level for the BAC-11-1 jets which, as we have shown before, is obviously greater than for the IL-18 turboprops.

Another conclusion to be drawn is the fact that for most of the groups of professions investigated and, especially, the mechanics, the low frequencies are considerably more affected than the high frequencies. An exception is group I (executive officers) in which, owing to a relatively advanced average age, a physiological drop in hearing makes itself felt at high frequencies as a function of age (presbyacusia).

In another airport occupational category that has received less attention in previous studies, namely, drivers of all kinds of motor vehicles, a pronounced drop in hearing at low frequencies also can be observed. This is due to the fact that while stationed on the landing field, many airplanes have their engines running or other assemblies are running on the airplane or on the ground (fuel tanks, electric feeders, etc.), which create a high, quasi-permanent background noise, to which must be added the brief, but very intense, noises caused by the takeoff and taxiing of airplanes, which are the conditions under which motor vehicle drivers are obliged to carry out the greater part of their tasks. /70

From the foregoing we can draw the following conclusions about the parallelism between airport noise parameters and the degree of hearing impairment in exposed personnel:

-- the sound spectrum of jet aircraft covers a much wider range of frequencies up to the ultrasonic region, unlike that of aircraft with classical engines, in which low-frequency noises predominate;

-- the harmfulness of noises is the more pronounced, the higher their frequency;

-- the noises generated by BAC-11-1 jets are clearly more intense than those generated by IL-18 turboprops, which they exceed in all phases of operation (taxiing, takeoff, flight, landing);

-- audiometric determinations carried out on airplane mechanics have revealed that the hearing of mechanics who service the BAC-11 is considerably more affected than that of those who service the IL-18.

These conclusions illustrate the danger that airport noise entails for service personnel and, especially, mechanics.

Consequently, effective measures are necessary for the prevention of hypoacusia and other noise-induced morbid phenomena.

HEARING THRESHOLD FOR DIFFERENT OTOPENI AIRPORT OCCUPATIONAL GROUPS. /71

Group	Occupation	Average Age (Years)	Average Length of Service (Years)	Hearing Threshold (in dB) for Frequencies (in kHz)					
				0.5	1	2	3	4	6
I	Executive officers	43	21	30	23	17	21	42	36
II	IL-18 mechanics	28	9	35	27	21	17	18	24
III	BAC-11-1 mechanics	28	10	41	30	24	25	27	28
IV	Technicians	30	6	31	26	18	22	35	32
V	Dispatchers	24	1.5	34	23	16	11	16	18
VI	Motor vehicle drivers	38	4	39	28	21	25	32	32
VII	Others	31	4	37	27	21	19	17	19

Summary /72

The present study deals with the degree of hearing impairment in the service personnel of Otopeni International Airport, which was determined by the method of tonal audiometry. Comparative analyses are given of the noise level caused by the two categories of aircraft used at the airport (jets and turboprops). The subjects were recruited from among the different occupational groups that characterize this airport, and the results are correlated with the intensity of the sound field, length of exposure, age and length of service.

CHANGES IN THE CRITICAL FUSION FREQUENCY THRESHOLD FOR INTERMITTENT LIGHT IMAGES AND THE MOTOR REACTION TIME OF WOMEN WORKERS IN SPINNING DEPARTMENTS

C. Ursoniu, A. Dankner, and A. Sirbu
Timisoara Institute of Medicine,
Medical Research Center, Timisoara, Romania

In view of the great number of women working in spinning departments under conditions of occupational noise exposure, our research was aimed at estimating the stresses to which their organism is subjected with the aid of highly sensitive psychophysiological tests. In the course of our comparative investigations we recorded the values obtained before and after work in 99 women spinners. /73

Research Methods Employed

1. Noise intensity was measured with a Bruel and Kjaer 3501 sonometer. Audiospectrograms were plotted for the total noise intensity as well as for the intensity in different frequency ranges.

2. Measurement of the critical fusion frequency (CFF) threshold for intermittent light images with an Apelimex Mecascope Lavallois stroboscope which we adapted to this purpose. The measurements were effected before and after work, the mean values for ten determinations being calculated separately for each person.

3. Measurement of the latent motor reaction time (MRT) with the aid of an electronic device which we adapted to this purpose. This consists of an IFA "Numedit 744" electronic computer provided with digital electronic circuits, which permits very accurate and rapid measurement of frequencies and time, the result being presented in numerical form in 10^{-3} seconds. Determinations were effected for visual, auditory and tactile stimuli before and after work, the mean value of ten determinations being calculated separately for each person.

Results /74

1. Measurement of noise intensity in spinning departments brought to light the presence of high values in the 1000-8000 Hz frequency range, the total noise intensity varying from 92 to 97 dB.

TABLE 1. NOISE INTENSITY VALUES IN DIFFERENT FREQUENCY RANGES IN DIFFERENT SPINNING WORK SPACES.

Exp. No.	f (Hz)	Noise intensity (dB) 1	2	3	4	5	6	7	Cz 85
1	31,5	74	80	84	83	88	83	90	110
2	63	82	84	83	80	80	87	87	103
3	125	84	89	87	82	85	87	88	96
4	250	88	87	90	84	84	86	88	91
5	500	88	88	88	85	84	88	89	88
6	1000	87	84	91	85	85	89	88	85
7	2000	85	81	89	81	81	88	84	83
8	4000	85	75	84	73	76	86	81	81
9	8000	86	71	82	69	73	88	78	80
10	16000	80	62	74	62	69	78	75	79
11	31500	60	40	56	44	56	61	60	78
12	Ln	96	94	96	92	92	97	96	
13	C	95	94	96	91	91	96	95	
14	B	94	92	95	89	90	95	93	
15	A	93	89	94	88	88	94	91	

2. Measurement of the CFF threshold for intermittent light images before and after work showed a drop in this threshold at the end of work in 30.3% of the 99 women working in the spinning department.

TABLE 2. MEAN, MAXIMUM AND MINIMUM VALUES OF CFF THRESHOLD BEFORE AND AFTER WORK.

Values Before Work /brightnesses/sec/			Values After Work /brightnesses/sec/		
Mean	Maximum	Minimum	Mean	Maximum	Minimum
41.3	51.6	35.8	39.7	48.5	35

3. Measurement of motor reaction latency time brought to light a lengthening of this time after work in 69.6% of the cases for the visual stimulus, in 77.7% for the auditory stimulus and in 78.7% for the tactile stimulus. /75

A lengthening of reaction time for all stimuli employed was encountered in 48.3% of the cases examined.

Discussion of Results

What characterizes occupational exposure to the harmful action of noise in spinning departments is the exceeding of Cz 85 dB in the 1000-4000 Hz frequency range, the total noise intensity reaching 97 dB.

Under these conditions the significance of stresses to the organism during the technological process is illustrated by the results obtained with the aid of the two tests we used.

Measurement of the CFF threshold constitutes a very useful test for estimation of auditory fatigue.

Subjectively, the CFF threshold represents the moment when the discontinuous brighnesses of the stroboscope's light source are perceived by the person tested as a sensation of continuous light. Objectively, electroretinogram recording shows that a luminous excitation of the flash type gives rise to a complex electric response characterized by a small negative wave followed by a positive wave.

Studying the fusion of light images that accompanies flash excitation, Baron, Thieffry and Kahn electroretinoencephalographically recorded electric potential differences in the retina of both eyes, in the optic pathways and in the optic center.

As a result of the light stimulus a retinian electric response was observed which appeared in 1/30 sec, followed by an occipital electric response in 2/30 sec. The magnitude of the light stimulus frequency led to a transformation of the peripheral and central electric response. Thus, changes in shape and duration of retinian electric waves were observed, and the potential differences dropped until the appearance of a limiting value.

Whenever the retinian electric waves alternate and are repeated identically, without showing variations in shape and duration, the light images are fused as a sensation of continuous light for discontinuous light brighnesses. At the same time, changes in the occipital electric potentials could also be observed. /76

The cited authors show that the CFF test explores the operation of the CNS and, especially, of the optic pathways with their different neuronal, peripheral, intermediate and central stages, as well as the reticular formation, the regulating and controling center for information that reaches the cerebral cortex and for the orders that leave from it.

Many anatomico-functional systems explored with the aid of the CFF threshold attest to the usefulness of this test for estimation of CNS stresses under different production conditions.

Under normal conditions the CFF threshold would be situated between 38-40 brightnesses/sec (Parmentier-Beloux, J. Ripoche). This threshold varies within rather wide limits as a function of the device and technique employed.

The significance of stresses to the organism in spinning departments is illustrated by the results obtained, which showed a drop in the CFF threshold in 30.3% of the workers examined. The usefulness of this test is demonstrated by the results we obtained in previous studies carried out in different production centers.

Measurement of motor reaction time with the aid of the Numedit 744 permitted measurements on the order of 10^{-3} sec, their accuracy being especially great. MRT represents the period between application of a visual, auditory or tactile stimulus and the motor response of the subject being investigated (A. Rosca).

Let us mention that the mean values we found in the 99 spinners confirm the observation that the MRT is longer for visual stimuli than for auditory or tactile stimuli. The mean values we obtained before work, compared with those found by Woodworth-Schlosberg, are given in the following table.

TABLE 3. /77

Exp. No.	Stimulus	Our Results	Woodworth-Schlosberg
1	Visual	220 ms	180 ms
2	Auditory	180 ms	140 ms
3	Tactile	190 ms	140 ms

The lower values found by the cited authors are probably due to the fact that they worked under experimental laboratory conditions with trained persons. To be noted, however, is the fact that the order of magnitude of the differences between the values is preserved, being about 40-50 milliseconds. The results bring to light an important stress to the organism, a lengthening of the MRT of the function of the stimulus utilized being encountered in 69.6-78.7% of the spinners.

Conclusions

1. In spinning departments there is considerable occupational exposure to the harmful action of noise with an intensity varying from 92 to 97 dB.

Audiospectrographic plotting disclosed an exceeding of Cz 85 dB in the 1000-8000 Hz frequency range.

2. Measurement of the CFF threshold showed a drop in this threshold after work in 30.3% of the spinners.

3. Measurement of MRT showed after work a lengthening of opticomotor response time in 69.6%, of audiomotor response time in 77.7% and of tactilomotor response time in 78.7% of the women working in spinning departments.

4. The results obtained with the aid of the methods we used illustrate the significance of stresses to the organism under conditions of occupational exposure to noise in spinning departments.

Summary /79

Research was carried out in a spinning department of the textile industry. Noise intensity measurement showed that Cz 85 dB was exceeded in the 1000-8000 Hz frequency range, total noise intensity being 96 dB. Measurement of the critical fusion frequency threshold for light images before and after work showed a drop in this threshold after work in 30.3% of the workers examined. Measurement of motor reaction time disclosed after work a lengthening of opticomotor response time in 69.6% of the cases, of audiomotor response time in 77.7% and of tactilomotor response time in 78.7%. The changes we found illustrate the importance of stresses to the organism during work in spinning departments.

REFERENCES /77

1. Baron, J.B., J. Kahn, P. Rey, XVI-th International Congress on Occupational Health, Madrid, 1963, Vol. III, pp. 1381-1382.

2. Grandjean, E., Principii de ergonomie [Principles of ergonomy], Edit. Stiintifica, Bucharest, 1972. /78

3. Parmentier-Beloux, M. and J. Ripoche, Presse Med., 41, 1565-1567 (1959).

4. Rosca, A., Tehnica psihologici experimentale si practice [The method of experimental and practical psychology], Cluj, 1947.

5. Ursoniu, C., A. Dankner, F. Schneider, and G. Silas, Ergonomics in machine design, Vol. II, International Labor Office, Geneva, 1969, pp. 707-711.

6. Ursoniu, C. and F. Gavrila, Activitatea stiintifica [Scientific activity], Institutul de Medicina Timisoara, 1970, p. 719.

7. Ursoniu, C., A. Dankner, N. Puca, G. Silas, T. Cioara, and L. Lipovan, Timisoara Medicala 1, 47-52 (1971).

8. Woodworth-Schlosberg, Experimental psychology, Holt-Rhinehart and Winston, Inc., New York, 1961.

CLINICAL CONSIDERATIONS ON SOUND POLLUTION IN THE HUNEDOARA IRON AND STEELWORKS

Ion Malaiu, Walter Nikels, Cornelia Disconescu, and Maria Bichis
Hunedoara United Hospital, Romania

The sound pollution problem is continually being brought up in all countries because of its many clinical and experimental aspects that have not yet been elucidated. /81

The rapid growth of industry in Romania obliges us to study labor conditions in noisy environments, to ferret out at an early time those who are predisposed to deafness and to implement the most adequate prophylactic measures.

In combating industrial noise we must be guided in the first place by continuous concern for the health of the workers and in the second place by considerations of national economy because noise, as a traumatizing factor, causes a drop in work productivity.

The purpose of the present article is to give information about sound traumatism in a number of departments of the Hunedoara Iron and Steelworks and to contribute to the prevention of deafness by sound pollution.

Methods and Materials

In the present article we shall analyze and express our opinion of the effect of sound pollution on the organ of hearing. /82

Our examinations were carried out periodically in the course of several years. They involved 370 workers of the Blower-Electric Steel Mill -- Blooming departments, where on-the-job measurements showed a noise intensity above 100 dB.

From among these 370 workers we eliminated 21 cases showing thoracic and other affections which might have influenced our results.

These examinations were effected only outside working hours with the exception of blood pressure-pulse, which was taken on the job and during rest periods. Our investigations involved personal case histories, otorhinolaryngologic examination, as well as functional examination of the ear by means of phonic acumetry, both instrumental and radioelectric, as well as spontaneous vestibular tests.

The audiograms were recorded with an MA 3 audiometer in a soundproof cabin of the ORL service of the company's polyclinic.

Results and Discussion

The case histories show that 65% of the workers are smokers and moderate daily consumers of alcohol.

We observed nervous disorders for the most part in the young workers between 20-30 years of age and in those who experience in their work space vibrations due to the speeds and accelerations undergone by sections of the floor under their feet; 12% were receiving neuropsychiatric treatment for irascibility, insomnia, physical asthenia. Thirty percent showed acousmas in the form of /83
the noises tending toward acute tonality that are characteristic of hypoacusias of perception.

In workers with more than 10 years of service we also recorded variations in the blood pressure and pulse, with an increase in blood pressure and pulse during service.

In 85% the otoscopic appearance of the tympanic membranes was normal.

Out of a total of 349 audiograms, we found hypoacusias through sound traumatism in 86 cases in stage I, 42 cases in stage II and 39 cases in stage III.

By age: 20-35 years: 46 cases; 35-45 years: 68 cases; 45 years and over: 53 cases.

Phonic and instrumental acumetry disclosed a diminution for whispered voices and, depending on length of service, also for conversational voices; and in the 1028 dv, 2048 dv range, a reduction in the osseous curves.

Vestibular examination consisted in a search for spontaneous nystagmus and rombergism with nystagmus.

We observed positive rombergism and the appearance of more intense nystagmus in newly-hired workers. Because some authors maintain that the pneumatic retrotympanal system plays a protective role, we recorded radiograms of the mastoid regions in order to determine whether the degree of pneumatization has any effect on predisposition or resistance to sound traumatism; from this point of view we did not obtain sufficiently conclusive data to /84
draw conclusions.

Inasmuch as our statistics involved an insufficient number of (associated) otic affections, we are unable to form an opinion as regards their correlation with sound traumatism.

From our studies it follows that resistance and sensitivity to noise depend on individual differences and that this individual susceptibility to noise is connected with different constitutional factors that have not been elucidated to this time.

The problem of sound traumatism at the Hunedoara Iron and Steelworks can be summarized as follows:

1. Cases of hypoacusia through sound traumatism must be declared at once.

2. Hospitalization and free periodic medication consisting of vitamin therapy (B complex and vitamin A), sedatives, tonics.

3. A raise for those who work in a noisy environment.

4. Reassignment of cases showing otic affections incident to hiring and cases with a history of affections which, according to some authors, involve a reduction in resistance of the auditory organ.

5. Mandatory wearing of plastic earplugs; nevertheless, some workers refuse them on the grounds that they prevent them from being aware of the normal operation of their machines in the event of a disturbance of the technological process.

6. In collaboration with the labor protection union and the local trade union community we succeeded in ensuring a quiet, soundproof place for taking meals; the avoidance of overtime insofar as possible; and through sanitary education we showed the importance of weekly rest and annual leaves to be passed in resorts or other quiet environments. /85

The most difficult problem to solve is that of the prophylaxis of sound traumatism by means of changes in the technological process, which are difficult to bring about; this would amount to a complex change in the factory; for this reason our attention was more concentrated on individual prophylaxis.

Conclusions:

1. Sound traumatism constitutes an occupational noxa in the Blower-Electric Steel Mill, Blooming department.

2. Individual sensitivity is the main factor in the production of the sound noxa.

3. In terms of hypoacusias by age, it can be observed that in older workers, the hearing loss is more pronounced (stage III) as compared with young workers, who fit into stage I.

4. In terms of hypoacusias by length of service, a greater percentage occurs in workers with more than 10 years of service as compared with those who have been working between 1-5 years.

5. The solution of sound pollution remains a problem of collaboration between medical and technological teams.

Summary /87

The present study discusses the problem of sound traumatism in a number of departments of the Hunedoara Iron and Steelworks, where noise as a traumatizing factor can lead to a drop in productivity, and makes a contribution to the prevention of deafness through sound pollution.

Our investigations involved 370 workers in the Blower; Electric-Steel Mill; Blooming departments, where on-the-job measurements showed a noise intensity above 100 dB.

Our examinations were conducted only outside working hours, and included case histories, functional examination of the ear by means of instrumental and radioelectric phonic acumetry, and spontaneous vestibular tests.

On the basis of our study of the sound pollution problem at the Hunedoara Iron and Steelworks, we suggest the following: obligatory declaration of cases of hypoacusia through sound traumatism; their hospitalization; periodic check-ups; free medication; reassignment; raise and reorientation for cases in which the history shows affections which might lead to a reduction in resistance of the auditory organ.

Portman, "Sound traumatism," Revue de Laringologie-Otologie-Rinologie (1960).

Moumler, Kuhn, Lafon, and A. Margou, "New ideas in the etiology of occupational deafness." [sic]

Rosen, Samuel, "The effect of noise and age on hearing and other functions." [sic]

Ghibus, Ioan, (Oto-sono-trepidoza), 1964.

Costinescu, Girbea, Racoveanu, Tetu, Editura medicala [Medical Publishing House], Manual 1964, Vol. II [sic].

Girbea, S., N. Albu, and E. Bolza, Revista Oto-rino-laringologie 3 (1964).

Tetu, I. and N. Apostol, "The role of pre-existing otopathies in sound traumatism," Oto-rino-laringologie 1 (1964).

ACOUSTICAL STUDY OF CONFORMATIONAL CHANGES OF NUCLEIC ACIDS IN WATER SOLUTIONS

/89

F. I. Braginskaya
Institute for Physical Chemistry, Academy of Sciences of the USSR, Moscow

Summary

A correlation between nucleic acid (DNA and RNA) acoustic properties in water solutions and their conformational changes was revealed. The ultrasonic absorption coefficient was measured in a pulse device over the frequency range 12 to 68 MHz. The minimum mean relaxation time of DNA heat denaturation was calculated on the basis of acoustic measurements. It was determined that breaks in the RNA chains, as a result of hydrolysis, leads to a decrease in ultrasonic absorption in water solutions of it; the kinetic characteristics of RNA alkaline hydrolysis were studied from ultrasonic absorption relaxation data.

/90

Acoustical measurements in water solutions of biomacromolecules can give information on the internal structure of biological fluids and on the nature of rapidly occurring molecular reactions, the duration of which is comparable to the period of ultrasonic (US) waves [1-4]. Data are presented in the report, indicating the presence of a definite correlation between changes in the relaxation spectra and the nature of directional changes in nucleic acid structures, which permits quantitative time characteristics of the changes to be determined. This is essential for study of their functional mechanisms.

Measurements of the absorption coefficient of ultrasonic waves (α/f^2) were made in a pulse device, over the frequency range f = 12-68 MHz at 20°C [3,4]. The measurement error is ±3-5%. The equation

$$\left(\alpha/f^2\right)_{meas} = \frac{A}{1+(f/f_0)^2} + B \quad [5]$$

was used for description of the relaxation process.

We showed earlier [4] that the correlation of US absorption of water solutions of DNA with pH, at frequencies of 12 and 20 MHz, has an extreme nature in the pH 12 region. The maximum US absorption in the alkaline pH region, at which alkaline denaturation of DNA takes place, can, however, be due to a proton transfer reaction. Therefore, the conformational changes in DNA, connected with heat denaturation at neutral pH, were studied by the US method in this work.

The frequency correlations of US absorption (α/f^2) in solutions of native DNA and RNA, subjected to heat denaturation and alkaline

hydrolysis, respectively, are presented in Fig. 1. The US absorption coefficient in this case decreases nonlinearly with frequency, which is due to relaxation phenomena. An increase in α/f^2 is observed in denatured DNA solution, as in the case of disordering of DNA or RNA structures by chemical agents [3,4]. On the other hand, breaks in the nucleic acid chains, as a result of alkaline hydrolysis, as is evident from the figure, leads to a decrease in attentuation of US energy. /91

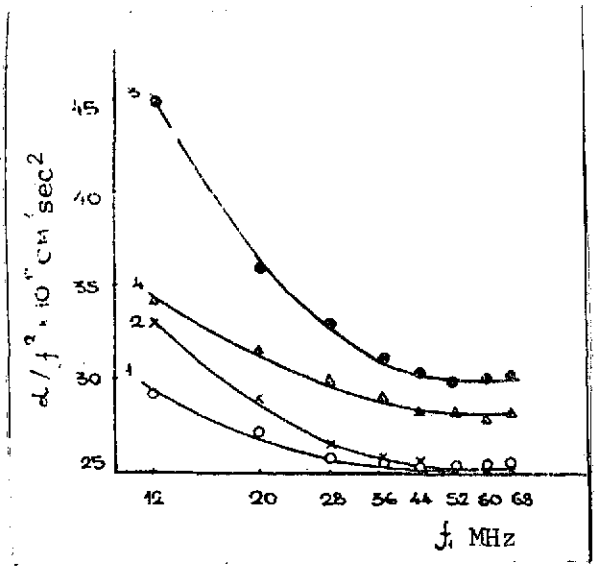


Fig. 1. Ultrasonic absorption spectrograms in water solutions of native (curve 1) and denatured (curve 2) thymus DNA (concentration 0.001 g/ml in 0.01 M NaCl, pH 7, T = 20°C); and in water solutions of RNA before (curve 3) and after (curve 4) alkaline hydrolysis at 98°, pH 9: RNA concentration 1.5 g/100 ml, T = 20°C.

An empirical formula usually is used for analysis of a single relaxation process, which permits calculation of τ_p of the process being studied, using experimental measurements of US absorption and other parameters. One such formula describes the relaxation process of chemical molecular dissociation [5]

$$(\alpha\lambda)_p = \frac{\pi (\Delta V^*)^2 C_0}{\beta_0 RT}\left[\frac{2-\bar{\varepsilon}}{\bar{\varepsilon}(1-\bar{\varepsilon})} + \left(\frac{\partial \ln K}{\partial \bar{\varepsilon}}\right)_T^2\right] \frac{\omega\tau}{1+\omega^2\tau^2} \quad [5]$$

/92

Assuming that denaturation of DNA can be considered to be a process of molecular dissociation of the double chain structure into a single chain one, we used this formula for the case being studied and calculated τ. In this case, $(\alpha\lambda)_p$ was calculated at 12 MHz by the difference in the corresponding values for native and denatured DNA. The calculated mean value of τ_p of heat denatured DNA was 6×10^{-8} sec. We note that the time for untwisting the double chain structure of DNA, i.e., untwisting the spiral sections, determined by the temperature jump method [6], is on the order of 10^{-2} sec. The relaxation time, calculated on the basis of ultrasonic measurements, is characterized, as one possible hypothesis, by the fastest reaction rate of the helix-coil transition of DNA, breaking the hydrogen bonds between the complementary bases.

The difference in absorption of US waves in solutions of native and denatured nucleic acids possibly is caused, as in the case of other biomolecules [2], by the reaction of the acoustic waves with the hydrated layer around the macromolecule. Relaxation of transverse viscosity apparently does not play a part in the mechanism of absorption of ultrasonic energy by DNA in the frequency range studied, since heat denaturation of DNA is accompanied by a decrease in its viscosity by almost two orders of magnitude, with extremely insignificant change in its US absorption (see Fig. 1, curves 1 and 2). The change in secondary structure of nucleic acids as a result of denaturation, possibly leading to decrease in hydration of the macromolecule [7], leads to an increase in US absorption of solutions of them. On the other hand, breaks /93
in the DNA and RNA chains cause a decrease in US absorption (see Fig. 1, curves 3 and 4).

The formation of mononucleotides by alkaline hydrolysis of RNA is a pseudomonomolecular reaction [8]; therefore, it is possible to use a first order equation for calculation of the hydrolysis rate constant and to calculate K graphically from the slope of the semilogarithmic anamorphosis curve. The kinetic curve of RNA hydrolysis, from measurement of the relaxation portion of the ultrasonic absorption is presented in Fig. 2, on a semilogarithmic scale.

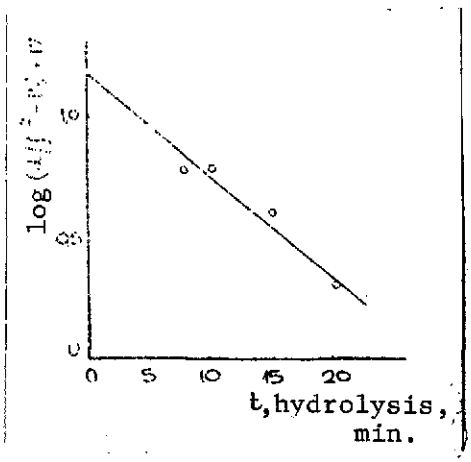


Fig. 2: Semilogarithmic relaxation portion of ultrasonic absorption of RNA water solutions vs. alkaline hydrolysis time.

The calculated value $K = 0.098\ min^{-1}$ is an apparent ("effective") rate constant of the alkaline hydrolysis of the RNA polynucleotide chain.

Thus, at neutral pH, US absorption spectra are evidence of wide distribution of relaxation processes. Decrease in US absorption in hydrolized RNA (see curves 3 and 4, Fig. 1), possibly is caused by a decrease in transverse viscosity, connected with a decrease in its molecular weight, as a result of hydrolysis. Moreover, breaks in the RNA polynucleotide chains possibly also induce changes in the molecular shape of the fragments formed, which could cause a change in polarization of the solution and, from this, a change in US absorption. Thus, disruption of the ordered structure of DNA induced by thermal denaturation and determined acoustically is caused by the mechanism of US absorption, apparently based on change in perturbation of the solute-solvent equilibrium by the US waves. As to changes in US absorption by RNA, as a result of the conformational changes studied, it possibly is connected with kinetic changes in the transverse viscosity, as a result of breaks in the chains in hydrolized RNA. /94

REFERENCES

1. Mikhaylov, I. G., V. A. Solov'yev and S. P. Syrnikov, Osnovy molekulyarnoy akustiki [Foundations of Molecular Acoustics], Nauka Press, 1964.

2. Dunn, F., P. D. Edmonds and W. I. Fry, Biological Engineering (4), (1969).

3. El'piner, I. Ye., S. Kh. Sadykhova and F. I. Braginskaya, Biofizika, 15, 26 (1970).

4. Braginskaya, F. I., S. Kh. Sadykhova and I. Ye., El'piner, Akustich. zh., 17, 465 (1971).

5. Mazon, U., Fizicheskaya akustika [Physical Acoustics], Mir Press, Vol. 2, 1968, p. 227.

6. Chapman, R. E. and I. M. Sturtevant, Biopolimers, 7, 527 (1969).

7. Choen, I. and D. M. Crothers, J. Mol. Biol., 61, 525 (1971).

8. Kochetkov, N. K. et al, in the book, Organicheskaya khimiya nukleinovykh kislot [Organic Chemistry of Nucleic Acids], Khimiya Press, 1970, p. 558.

THE BIOPHYSICAL EFFECTS OF ULTRASOUNDS ON CELL MORPHOLOGY

I. Hrazdira
Institute of Medical Physics, College of Medicine, Brno, Czechoslavakia

Introduction

The biologic influence of various physical factors seldom /97
takes the form of a linear relationship between the active force and the resultant biologic effect. In the field of ultrasounds the result depends on the characteristics of the ultrasonic field on the one hand and the properties of the biologic subjects on the other. The inhomogeneous structure of the biologic medium makes it extremely difficult to define the energy situation within the field with accuracy. For this reason the biophysical mechanism of ultrasonic action has yet to be determined.

The data on cell morphology after ultrasonic action given in the literature are not extensive, and attention has primarily been focused on study of the mitochondria [1, 2]. The goal of the present study was to reveal the complete pattern of infrastructural changes in cells subjected to ultrasonic vibration in relation to the test conditions.

Method

The studies were performed on surviving cells from rat bone marrow suspended in an isotonic Hanks solution. The sensitivity of these cells to ultrasounds has been demonstrated by our previous research [3, 4, 5]. The morphologic condition of the cells was studied either after directly subjecting the cells to ultrasounds or after incubating them in an irradiated medium (indirect action). The ultrasounds were produced by two generators: the TUR US 2

therapeutic generator, with a frequency of 800 kHz and a current intensity of 1 W/cm^2, and the UID S ultrasonic echography device, with a frequency of 100 kHz and an average current intensity of 20 mW/cm^2.

After ultrasonic treatment the cell suspensions were fixed in two phases using the Milonig technique. After fixation the samples were imbedded in Durcupan. Ultrafine sections obtained by /98
means of the Reichert ultramicrotome were examined under the Tesla 413 and 513 A electron microscopes.

Results

The direct action of ultrasounds on a cell suspension resulted in changes in all the structures, as we have already shown [6]. The degree of cell injury varied with the test conditions.

Changes were observed in the membranous structures as well as in the nuclei. The first changes included mechanical alterations in the cell membrane, up to complete disappearance of its typical structure. There were also marked changes in the mitochondria, which increased in size and became more rounded in shape. The mitochondrial matrix was very clear under the microscope and appeared to be empty. There were even changes in the cristae, which fragmented and widened into small "bursae."

Another infrastructural change which should be noted is the widening of granular endoplasmic reticulum "bursae." Broadened and rounded, this structure was sometimes extremely difficult to distinguish from an altered mitochondrion. Broadening of the membrane spaces also appeared typical for the agranular endoplasmic reticulum and for the Golgi component. The ribosomes became irregularly distributed over the membranous structure.

Nuclear changes primarily took the form of structural modifications of the chromatin. The chromatin granules became larger and their distribution became irregular.

The pattern of infrastructural modification after indirect action was visibly distinct from that obtained under direct influence. Incubation of surviving cells in a Hanks solution previously irradiated by ultrasounds produced moderate changes in the endoplasmic reticulum and the mitochondria. The other organelles showed no visible changes in infrastructure.

Discussion

The results show that it is primarily the membranous structures which are sensitive to the direct action of ultrasounds. The corpuscular structures, on the other hand, were changed only in regard to their spatial distribution. The lesions of the membranous structures, showing cell interfaces, were primarily of mechanical origin. The other lesions were of colloidal or osmotic origin. This may have been a question of thixopropia or of colloidal hydration changes resulting in anwidening of the membrane spaces. There were probably also osmiophilic changes related to osmotic changes in certain structures subsequent to the ultrasonic action. It has been possible to observe similar lesions hafter subjecting vegetal cells to ultrasounds [7, 8]. /99

Some lesions are characteristic of ultrasounds (primarily changes in the cell membrane). The changes in the mitochondria, however, are not this specific. The same microscopic appearance is obtained through action by other physical agents (ionizing radiation, high temperature [9, 10]).

Even though the changes in the mitochondria are less specific than the alterations in other cell structures, the biologic ef-

fect of ultrasounds can never be reproduced by other energy means. This effect is always of complex nature. The principal role in its mechanism is played by mechanical forces. However, an effective biophysical factor appears to be structural absorption resulting in physicochemical changes and a specific distribution of heat.

Conclusions

1. Direct action by ultrasonic vibrations of average intensity produces changes in all cell structures. The degree of change varies from small inner modifications to complete cell disintegration. The role of mechanical factors in lesions of the membranous structures is evident.

2. Both the indirect effects and the direct action of the low-intensity vibrations used in diagnosis are characterized, in the absence of mechanical lesions, by a moderate alteration in the endoplasmic reticulum and the mitochondria.

3. The biophysical action of ultrasounds is complex in nature. The primary mechanical effects lead to secondary physicochemical changes.

Summary /101

In synthetic studies of the biophysical effects of ultrasounds, changes in the ultramicroscopic structure of surviving cells (animal and vegetable) subsequent to ultrasound action were examined. The ultramicroscopic appearance of subjects examined in ultrafine sections showed changes in all cell structures, especially in the membrane and the nucleus. Evaluated in reference to the method of application of the ultrasounds, changes in the important cell centers constitute a morphologic basis for analysis of the effective biophysical factors in ultrasonic action.

REFERENCES

1. Borovyagin, V.L., and Elpiner, I.E., Biofizika 9, 312 (1964).

2. Dmitrieva, N.P., Biofizika 9, 571 (1964).

3. Hrazdira, I., Bilkova, B., Folia biol. 9, 397 (1963).

4. Hrazdira, I., Folia biol. 11, 330 (1965).

5. Hrazdira, I., Studia biophysica 2, 127 (1967).

6. Dvorak, M., and Hrazdira, I., Zschr. mikrosk.-anat. Forsch. 75, 451 (1966).

7. Hrazdira, I., and Havelkova, M., Naturwissenschaften 53, 206 (1966).

8. Havelkova, M., Strachova, Z., and Hrazdira, I., Folia microbiol. 15, 203 (1970).

9. Gamburceva, A.G., Glagoleva, V.V., and Basurmanova, O.K., Biofizika 11, 80 (1966).

CHANGES IN THE STRIATED MUSCLE MECHANOGRAM UNDER THE ACTION OF NONCAVITATIONAL SOUNDS

I.I. Nagy
Institute of Medicine, Timisoara, Romania

The specialty literature is not wanting in results obtained /103
by applying ultrasounds of different intensities and frequencies to neuromuscular preparations in vitro and in situ for the purpose of elucidating their mechanism of action. The reversible and irreversible changes undergone by living systems depend on experimental conditions (irradiation intensity, frequency and duration; etc.). Striated and smooth muscle respond with two-phase contractions; chronaxie in an ultrasonic field first decreases, then increases [5]. The role of the frequency of ultrasounds on the changes in chronaxie at different ultrasonic intensities (1-10 W/cm^2) has also been pointed out (M. Mazoné et al.).

Advances in the technology of generating and utilizing noncavitational ultrasounds have permitted cells to be studied with results interpretable at the molecular level.

The notion of noncavitational ultrasounds [4] refers to alternating vibrations with a low-pressure amplitude applied to the material to be irradiated by means of an acoustic transformer shaped like the frustum of a cone. The acoustic transformer is in contact with a magnetostrictive vibrator whose tip executes vibrations below 6.3 μm (cavitation threshold for macromolecules [4]), and the vibrator's adaptation to the acoustic transformer is optimal [2]. A noncavitational ultrasonic field produces microcurrents due to which the particles suspended in the cytoplasm execute symmetric motions about the virtual axis between vibrator tip and elastic membrane. The thickness of the perturbed stratum, the critical stratum, for biological media can be calculated on a good approximation with the formula: $d = 0.4\ f^{-0.5}$ cm, in which f = = the frequency in Hz.

The vibrator point can be regarded as a punctiform source of ultrasounds (spherical waves). Besides the appearance of micro- /104
currents within cells, another effect of the vibrations that is conspicuous under the microscope is a change in the contours of the cells, which does not disappear immediately with ultrasonic irradiation. For example, in the case of muscle fiber "folds" appear that are 15-20 times bigger than sarcomas [7]. The changes produced by these microcurrents also condition the equilibrium of the reciprocal spatial relations between the subatomic structures that participate in the process of muscular contraction.

The effects of noncavitational ultrasounds from the morphological point of view have not been brought to light [6], but their physiological effects are obvious [1, 12]. In most studies the low-pressure radiation frequency varies from 50 to 70 kHz.

The purpose of the present study is to determine the frequency value for a given intensity of the noncavitational ultrasonic field, at which a change occurs in the physiological state of striated frog muscle without any morphological changes being apparent. It is likewise proposed to determine the intensity value of ultrasounds at the "threshold" frequency which is accompanied by an obvious change in the striated muscle mechanogram.

Methods and Materials

The change in the mechanogram of the musculus gastrochemius of the frog in a noncavitational ultrasonic field at different frequencies can be studied by using an ultrasound generator [8] with a frequency that can be linearly adjusted between 10-300 kHz.

The frog under spinal anesthesia is in ventral decubitus on a table. The musculus gastrochemius is exposed and detached at the level of the distal insertion, the proximal part remaining attached to the leg together with the sciatic nerve. The distal head of the muscle is connected to the myograph stylus. The ratio of the stylus arms is 1:1, the passive arm being loaded with a 5.700-g lead weight. Electrical stimulation was effected by means of silver electrodes introduced into the muscle at the proximal head near the motor point of the sciatic nerve. The exciting electrodes were fed with rectangular pulses of liminal value (stimulation frequency was, depending on the case, 1-0.5 Hz) coming from a transistorized electrostimulator [9]. Let A_0 be the contraction amplitude. Noncavitational ultrasonic vibrations were introduced into the muscle by means of a 2-mm diameter acoustic transformer in contact with the exposed muscle and situated in the vicinity of the exciting electrodes. The transformer's axis is perpendicular to the path of the unexposed sciatic nerve. /105

The ultrasonic effect is studied against the background of electrical stimulation. The apparatus utilized is electronically controlled by an automatic device [10] so that the phenomena can be studied in time by means of automatic synchronization of several operations: starting of the kymograph drum, triggering of the electric stimuli, periodic coupling of the exciting coil of the ultrasonic transformer, synchronous coupling of the electromagnetic chronograph and of the Déprez marker. Tissue temperature is checked by means of a needle-shaped thermocouple. No temperature change can be observed during ultrasonic irradiation.

The experiment was conducted in the following stages:

In the first place, we chose an arbitrary and constant value of ultrasonic intensity (0.2 W/cm^2) at frequencies varying from 10 to 100 kHz. Let f_0 be the optimal frequency at which burst amplitude is maximal, $A_1 > A_0$.

Keeping frequency f_0 constant, we change the ultrasonic intensity for which the burst has amplitude A_1. Let this intensity I_0 be the optimal intensity. The relation between the two quantities f_0 and I_0 is studied as follows: the muscle's motor point is electrically stimulated as above, and a burst of amplitude A_0 is obtained. At different time intervals (from 60 to 60 sec) the muscle is irradiated with ultrasounds of intensity I_0 at different frequencies for 10 seconds. Figure 1 shows the tracing we recorded.

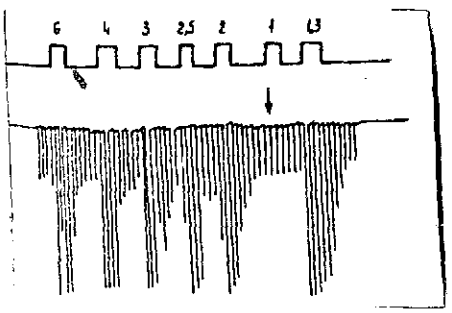


Fig. 1.

Results and Discussion

During electrical stimulation of the motor point of the sciatic nerve with pulses of liminal value bursts of a certain amplitude A_0 are obtained. For an interval of 60 seconds, for example, we coupled the generator which oscillates with a frequency of f_0 = 18 kHz at an intensity I_0 = = 0.20 W/cm^2. Burst amplitude A_1 is much in excess of the previous value A_0 throughout irradiation time (Fig. 1). This phenomenon could be attributed, we believe, to /106 a heightening of the state of synaptic excitation due to discharge of acetylcholine in the noncavitational ultrasonic field and to permeabilization of the motor plate. After decoupling of the transformer, bursts A_2, as a response to electrical stimulation after ultrasonic irradiation, have greater amplitudes than A_0, with a tendency to drop down to the initial value: $A_0 < A_2 < A_1$. A plausible explanation involves a vascular effect that improves metabolic exchanges and the muscle's functional capacity. The prolonged action of ultrasounds has also been pointed out by other authors [3]. By continuously decreasing ultrasonic intensity between 0.20-0.01 W/cm^2 we arrive at the "subliminal intensity" ($I > 0.01$ W/cm^2) at which the muscle no longer responds. The moment of ultrasonic irradiation is indicated by the arrow. The numbers 6, 3, 2, etc. of Fig. 1 are arbitrary and just indicate the ultrasonic intensity steps employed.

We believe that the action of the liminal intensity of ultrasounds causes spatial summation owing to the fact that the wave bundle, as the result of the concomitant excitation of several

presynoptic buttons, simultaneously releases chemical mediators into the synapses of the motor neuron, causing a maximal contraction. Incident to an increase in frequency above f_0 = 18 kHz at I_0 = 0.01 W/cm^2 burst amplitude decreases. At a frequency of 56 kHz a noncavitational ultrasound does not cause any change in the mechanogram (Fig. 2). The phenomenon can be attributed to adaptation.

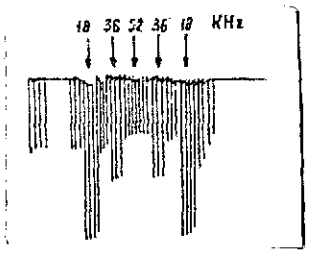


Fig. 2.

If we return to lower frequencies in the course of the same experiment, contraction amplitude increases (Fig. 2). The limiting frequency value shows no specificity for the individual. Figure 3 shows the frequency dependence of the concentration amplitude ratio, in which A_0 is the burst value as response to a liminal stimulus at the start of the experiment and A_1 equals the burst as response to ultrasonic liminal stimuli.

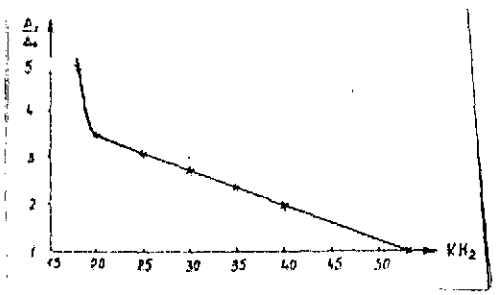


Fig. 3.

It should be mentioned that in the 10-18 kHz frequency range no change in amplitude A_1 can be observed.

Significant are the changes in glycogen level and in oxidation-reduction potential that accompany /107 muscular contraction [11].

Conclusions

1. Striated frog muscle in situ, stimulated electrically, responds to short-lived noncavitational ultrasounds with large bursts, if the frequency lies between 10 and 56 kHz and I = 0.20 W/cm^2. We regard 18 kHz as threshold frequency.

2. Maximum contraction occurs for a frequency of 18 kHz (threshold frequency) at I_0 = 0.01 W/cm^2.

3. In the interval between two irradiations, contraction amplitude remains increased and drops in time.

4. The contraction value is independent of ultrasonic intensity between 0.20-0.01 W/cm^2 (noncavitational interval) at the threshold frequency (f_0 = 18 kHz).

5. With a linear increase in frequency from 18 to 56 kHz at liminal intensity I = 0.01 W/cm^2 contraction amplitude decreases according to an exponential law; above 56 kHz no change in the mechanogram can be observed.

6. Determination of the ultrasonic intensity threshold for an optimal frequency measurable and reproducible in man, which causes a measurable contraction of a muscle, would, we believe, permit establishment of a biological dosage unit for ultrasounds.

7. This constant phenomenon is an aspect of the problem by means of which we can come closer to elucidation of the mechanism of action of the low-intensity ultrasounds that act on the human organism, especially at the low frequencies utilized in industry.

Summary /109

The effects of noncavitational ultrasounds on changes in the mechanogram of striated muscle in situ, stimulated by electrical pulses of known parameters, are investigated. It is found that the amplitude of the isotonic contractions induced by ultrasounds of strength I = 0.01 W/cm^2 is much in excess of that caused by the electric stimulus.

Further, the optimal frequency (f_0 = 18 kHz) at the liminal strength for a maximal contraction, as well as the relation between the changes in the burst amplitude and the frequency at the same strength, is established.

REFERENCES /107

1. Biofizika kleti [Biophysics of the cell], Akademia Nauk SSSR, 1965, pp. 140-151.

2. Blumenkrants, D.L., Z.I. Polyskov, "Choice of optimal dimensions of concentrators for ultrasonic devices of small power," Akusticheskiy zhurnal 19/1 (1973). /108

3. Busnel, R.G. et al., "Nervous excitability studied by means of ultrasounds," Actes de 73e Congrés de l'A.F.A.S. [Proceedings of the 73rd Congress of the AFAS], Poitiers, 16-22 July, 1954.

4. El'piner, I.Ye., Yu.M. Kaikin, O.K. Basurmanova, Biofizika 10, 805 (1965).

5. Hueter, F., Chem. Eng. Progress. Symposium Gen. 47, 51 (1951).

6. Lehmann, I., in Lampert: Ergebnisse der Phys. Ther. [Advances in physics], 1963.

7. Lyudkovskaya, R.G., I.M. Fakin, I.Ye. El'piner et al., Biofizika kleti [Biophysics of the cell], Nauka, Moscow, 1965, p. 140.

8. Nagy, I., "Ferrite-bar noncavitational ultrasound generator with many applications," Patent No. 2211-I.M., Timisoara, 1972.

9. Nagy, I., "Transistorized electrostimulator in widespread use for neuromuscular systems," Patent No. 12502, I.M., Timisoara, 1967.

10. Nagy, I., "Automatic device for kymograph control," Patent No. 12327, I.M., Timisoara, 1969.

11. Nagy, I., "Study of the action of noncavitational ultrasounds upon the redox potential of certain excitable systems," IV-th International Biophysics Congress, Moscow, 1972.

12. Nagy, I., "Methods for studying ultrasonic effects on excitable systems," Doctoral dissertation, I.M.F., Bucharest, 1971.

SPEECH UNDERSTANDING AND DISCRIMINATION OF SOUND SIGNALS IN THE CONDITIONS OF ACOUSTIC DISTURBANCE**

Z. Bochenek, I. Retajska, M. Zdrojewska-Turosiewska
J. Dawidowicz

CENTRAL RESEARCH CENTER OF THE RAILWAY HEALTH SERVICE
POLAND - WARSAW

In the process of understanding of received sound signals not only the acuity of hearing plays an important role but also other factors, such as attention of hearing, concentration ability, attention divisibility, memory of hearing and so on.

The development of psychoacoustic features depends on the degree of development of higher activities of the central nervous system. Some of them have an innate character, others are acquired by man in the cours of his life, e. g. during repeated actions in the work process. Can some acquired features compensate a deteriorated acuity of hearing ? The answer to this question is still difficult because we consider our tests as preliminary ones in the field of general psychoacoustic problems.

Methods

The test signal and disturbance signal were emitted simultaneously from the same loudspeaker in a silent room.

In the first testing cycle, was used a phonetically balanced mixed speech test, composed of words characteristic for work in the railway.

In the second testing cycle the test signal was the acoustically complexed whistle sound including a defined information

///

Reproduced from best available copy.

**The text of all articles written in English has been reproduced from the original book.

for the shunters.

The disturbance signal in both tests was an octave white noise filtered by filters of middle frequency 250, 500, 1000 and 2000 Hz given at the level of 60 and 90 dB_A. The disturbing signal was of a constant character, impulsed 12/sec.

Analysing the results we have taken a norm of test understanding in the limits from 80% to 100%.

Material

As test material 24 persons divided into 3 groups were used:

a/ young persons with normal hearing, having started work, as a control group

b/ shunters

c/ railway workshop workers.

All workers from group b and c showed clearly marked acoustic trauma.

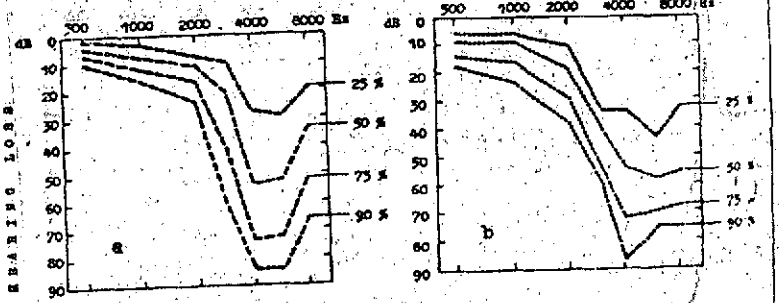


Fig. 1a Group audiogram of shunters

Fig. 2b Group audiogram of workshop workers

The 25% curve characterices hearing losses exceeded by 3/4 of persons in the tested group.

The 50% curve characterizes hearing losses which aren't exceeded by 50% of persons tested, i.e. this corresponds to avarege statistical losses.

The 75% curve characterizes hearing losses exceeded by 1/4 of persons tested.

The 90% curve characterizes hearing losses exceeded by 10% of persons, i.e. corresponds to a quasi-maximum losses.

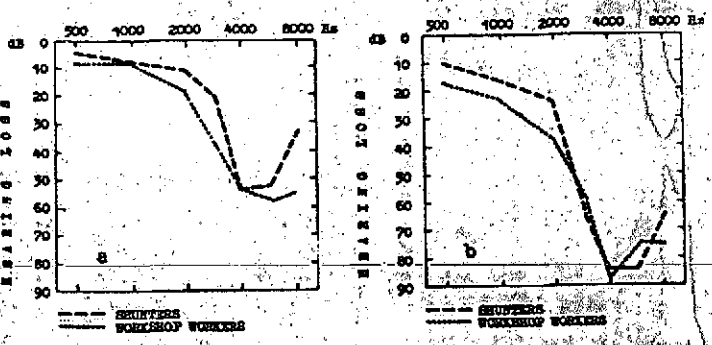


Fig. 2a Group audiograms of avarege hearing losses.

Fig. 2b Group audiograms of quasi-maximum hearing losses.

From fig. 2 it is evident that workshop workers showd a greater hearing losses than shunters, especially for frequencies from 500 to 2000 Hz.

Results

Results of laboratory testings for understanding of speech test are shown in fig. 3. From fig. 3 it is evident that by discrimination of railway instructions there is no distinct difference in the answers of control group and shunters group, however, the workshop workers group was less successful.

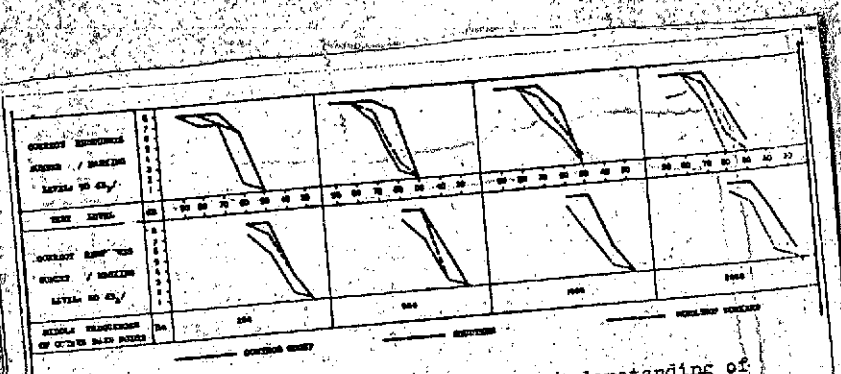


Fig. 3 Results of laboratory testing for understanding of speech test disturbed by octave band noise.

Results of laboratory tests for discrimination of whistle signals are shown in fig. 4.

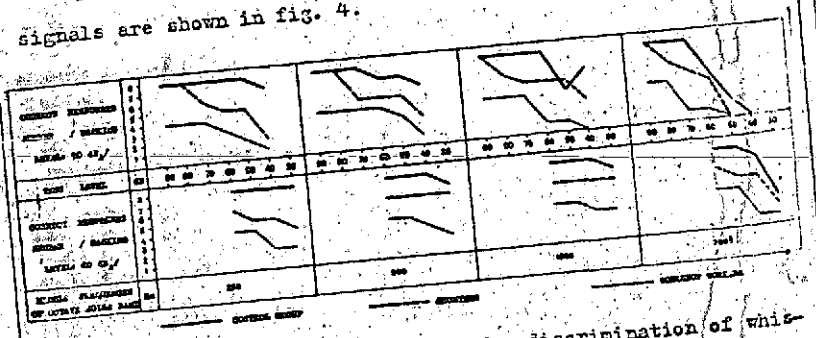


Fig. 4 Results of laboratory tests for discrimination of whistle signals disturbed by octave band noise.

From fig. 4 it is evident that in control group whistle signals were distinguished depending on the middle frequency of the disturbance band 20 to 50 dB below a 90-decibel disturbance level. Whistle signals disturbed by 60-decibel noise were distinguished 10 to 30 dB below the noise level, depending also on the middle frequency of the disturbance band.

In the shunters group almost all tested persons distinguished whistle signals transmitted 10 dB below a 90-decibel disturbance level, and some of them even 40 dB below the disturbance.

In the disturbance of 60 dB 6 persons distinguished transmitted signals still 30 dB below the noise level in bands of middle frequency 500 and 1000 Hz.

The workshop workers group distinguished whistle signals distinctly worse in comparison with previous groups by the disturbance of 90 dB as well as by 60 dB.

Comments

Tonal audiometry as well as supraliminal audiometry inform us first of all about the state of middle and internal ear. Speech-audiometry inform us about higher activities of the hearing process on the level of central nervous system. The divergences between audiometric and acoumetric results of testings give a basis to suspect the existance of pathological changes in the central nervous system. It may occur among others by sclerotic changes, in the process of aging and among persons with an acoustic trauma.

We are interested mainly in the influence of acoustic trauma on the process of speech and whistle signals understanding in the conditions of acoustic disturbance. A considerable hearing loss by 3 and 4 kHz frequencis may have an influence on speech understanding in noise. Then come out so-called delitescent deformations or their combinations which have no influence on speech understanding tested in silence.

On the other hand it should be considered if such a delitescent

/116

deformations cannot be compensated by other factors, e.g. psychoacoustic ones acquired in the course of work period. From the results of our testsit is clear that an average loss of hearing in workshop group of 'orkers was a little higher then in the shunters 'group. The results obtained by the application of speech test, well known to all railway workers, have corresponded with the above results. However, the answers-obtained by discrimination of whistle signals were difinitly worse in workshop group of workers whe in their everyday-work don 't use this signalisation. This phenomenon can be explained by the lack of acquired acoustic memory among workshop workers contrary to-shunters who have worked out such a feature in process of work.

/117

Summary

There are other factors, besides the acuity of hearing, that also play a role in the process of understanding of received sound signals, namely psychoacoustic factors. We consider our tests as preliminary ones in the field of general psychoacoustic.

24 persons were examined by means of speech audiometry and whistle signals in the conditions of disturbance by octave white noise filtered by filters of middle frequency (250, 500, 1000 and 2000 Hz). In spite of acoustic trauma in the threshold curve the reception of information included in the test signals was much better among persons using such signals in their daily professional work.

EFFECTS OF ULTRASONICS ON CHANGES IN BIOLOGICAL PROPERTIES OF BAKER'S YEAST

/119

F. I. Braginskaya, K. Ye. Kruglyakova, V. A. Yermachenko, T. V. Rusanova
Institute for Physical Chemistry, USSR Academy of Sciences, Moscow

Summary

The kinetic characteristics of certain biological singularities of Saccharomyces cerevisiae yeast cells, subjected to the effects of low frequency ultrasonic oscillations was studied. The relations were shown to have an exponential nature. The rate constants of the change in numbers of dead and viable cells were calculated at various ultrasonic wave intensities. A kinetic analysis /120 was carried out of change in fermenting activity of sonicated yeast. The optimum conditions for increase in fermenting activity of baker's yeast, using ultrasonic energy, were selected, based on the results obtained.

The search for an effective method of increasing the rates of fermentation processes is of considerable scientific and practical interest. At the present time, highly interesting facts, from the scientific and practical viewpoints, have been accumulated, concerning the use of ultrasound, not only as a method of distinguishing biological structures or enzyme systems, but as a specific factor of action on live cells. Study of the kinetic characteristics of these processes is not only of scientific interest, but it plays an important part in technology. The kinetic characteristics obtained in this case can be used for both description of the mechanism of action of ultrasonic waves and to develop effective methods of ultrasound action on fermenting activity of baker's yeast.

The effect of ultrasonic waves on pressed baker's yeast strains was studied.

Sonication of the yeast cells was carried out in a type UZDN-1 low frequency ultrasonic disperser, with exponential radiator. The sonication intensity was changed by means of change in current strength (I, A) supplied to the generator tube circuit; sonication temperature was +4-+12°C.

The effectiveness of ultrasound on yeast suspensions was studied, as a function of various factors: sonication intensity, duration of sonication, yeast cell concentration, etc.

Ultrasonic waves of specific intensities have a disrupting /121 effect: cell breakdown is observed when the ultrasonic oscillation intensity is sufficient for the appearance of cavitation in the sonication medium.

Institut [illegible], Akademii Nauk SSSR, Moscow

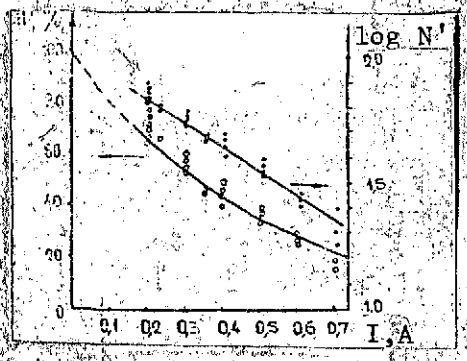


Fig. 1

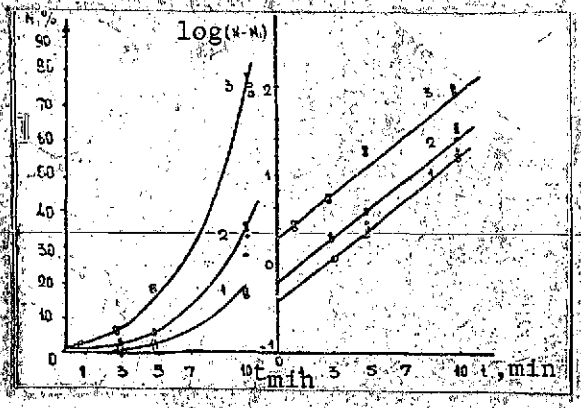


Fig. 2

For purposes of selecting the sonication conditions, the percent viable cells (N') in yeast suspensions vs. sonication intensity (I, A) (Fig. 1), during sonication exposure of 10 min, and the percent dead cells (N) for various sonication intensities vs. sonication duration (Fig. 2, curve 1 at I = 0.2A, curve 2 at I = 0.5A, curve 3 at I = 0.7A; N_1 is the percent dead cells in unsonicated suspensions), were investigated. The kinetic curves of disruption of yeast cells is well described by an exponential relation. The decrease in percent viable cells and increase in percent dead cells in sonicated yeast suspensions, calculated from the slopes of the corresponding semilogarithmic anamorphosis constants, were 2×10^{-1} and 0.37 min^{-1}, respectively, for the ultrasonic oscillation intensities studied. /122

Thus, the kinetic analysis of the effect of ultrasound on yeast cells (by morphological indications) permits quantitative parameters characterizing this process to be obtained. The latter allowed the optimum conditions (sonication time 10 min, yeast concentration 4%) and modes of ultrasound generation for cell breakdown, to be found for extraction of biologically active substances. The biological activity of the yeast cells was studied by their fermentation of a saccharose substrate (Q_{CO_2}) and by the buoyancy of the yeast (time for a dough ball to rise, T_{min}; increase in the latter is evidence of a reduction in fermenting activity of the yeast).

Kinetic curves of fermenting activity (in curve 1) and buoyancy (curve 2) of yeast vs. sonication time and the corresponding semilogarithmic anamorphoses (b) are represented in Fig. 3a. It is clear from the figure presented that fermenting activity of enzymes of sonicated yeast cell sets decreases noticeably. In this case, a definite correlation is noted between the extent of suppression of fermenting activity and reduction in buoyancy of the yeast. The curves are described well as an exponential relation, with equal values K = 0.15 min^{-1}, calculated from the slope of the corresponding semilogarithmic anamorphoses. In specially set up /123

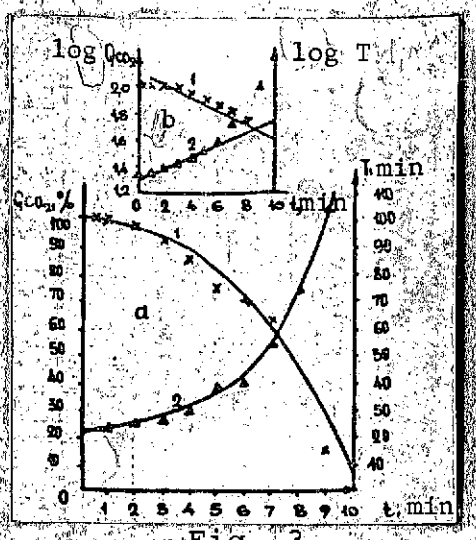


Fig. 3

tests, using various original procedures, it was successfully shown that the fermenting activity of yeasts considerably increases with addition of sonicated suspensions to unsonicated ones in a definite ratio, while strictly preserving the total quantity of yeast biomass.

Curves of carbon dioxide given off as a result of saccharose fermentation (Q, mM CO_2/g dry weight) of control yeast suspensions (curve 1), sonicated ones (curve 2) and a mixture of sonicated and unsonicated yeast, in a 30:70 ratio (curve 3) vs. duration of fermentation, hours, are presented in Fig. 4a. It should be noted that, while time when the fermenting activity of sonicated suspensions is considerably reduced and is suppressed by the third hour of the process, the fermentation process is considerably increased in a mixture of sonicated and unsonicated yeast.

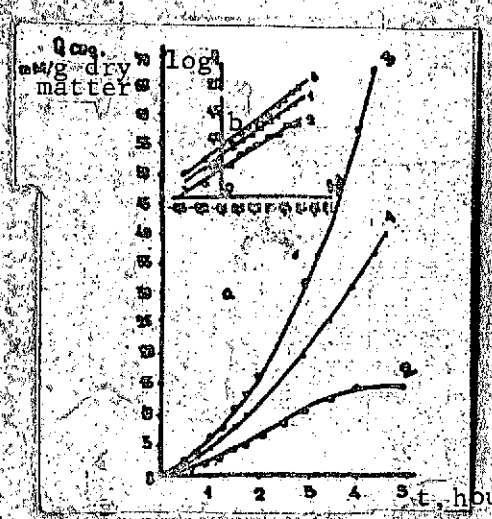


Fig. 4

As is clear from Fig. 4b, the kinetic curves of Q_{CO_2} vs. fermentation time can be described by the power function $Q = Q_0 t^n$, and the kinetic curves of the process being studied are rectified well in log-log coordinates. The values of n found experimentally for the sonicated suspension, control suspension and mixture are 1.29, 1.40 and 1.58, respectively. The differences as found in the time exponent (t^n) are evidence that, during the fermentation process, fermentation of the mixture of sonicated and unsonicated yeast takes place more intensively than that of the control suspension. /124

In this manner, the results presented show that addition of sonicated yeast to unsonicated leads to acceleration of the fermentation process. In this case, specially set up tests showed that the nature of the fermentation process is unchanged. Scientifically, study of the mechanism of acceleration of the fermentation activity of yeast cells is significant. The fermentation acceleration process, with addition of sonicated yeast suspensions,

can be caused either by extraction of biologically active substances from the yeast cells by the ultrasound or connected with change in the cell structure of the sonicated cells. It was noted that the death of Saccharomyces cerevisiae 196-6 yeast cells was not always accompanied by disruption of the cell membranes. Observations by luminescence microscope showed that the sonicated cells were deformed in a number of cases and that their membranes acquire irregular, angular shapes. This fact indicates that the effect of ultrasound on the yeast cells is not reduced only to mechanical disruption of the biological structure but, here apparently, fine disruptions concerning the organization of the membrane and the molecular complexes connected with it take place (El'piner, 1966).

Thus, the question here may be of a direct effect of ultrasonic energy on the function and structure of a series of biocomplexes, possibly connected with yeast cell membranes.

MATHEMATICAL MODEL OF THE ULTRASOUND EFFECT ON RED CORPUSCLES

E. Veress and J. Vincze
Babes-Bolyai University, Cluj, Romania; Institute of Medicine, Cluj, Romania

In order to bring out the destructive effect of ultrasounds /127 on diluted cellular suspensions, we chose as experimental material suspensions of rat erythrocytes.

The purpose of the present work is to find a mathematical model for the effect of ultrasounds on suspensions of rat erythrocytes based on experimental determinations, which could be applied also to the case of other types of erythrocyte suspensions. Such a model would permit theoretical estimation of any of the following parameters: the time necessary to obtain hemolysis, the ultrasonic field intensity, the volumetric concentration of the suspension.

Measurements were carried out with a Tesla piezoelectric generator at a constant ultrasonic field frequency of 1 MHz and an intensity varying from 0.2 to 1.2 W/cm^2.

Fresh blood was collected on heparin (0.2 mg heparin per 1 mℓ blood) and was centrifuged for 10 minutes at 3000 rps. After separating the erythrocytes and washing them 2-3 times in the centrifuge, we prepared suspensions of the erythrocytes with the desired volumetric concentration (0.5%; 1.0%; 1.5%; 2.0%).

The prepared suspensions were shared out among 16-mm diameter, /128 100-mm high, flat-bottomed glass vessels especially adapted for ultrasonic irradiation.

We used 1 mℓ of each sample at the six different ultrasonic field intensities, the different treatment times in the ten repetitions and the different volumetric concentrations, the temperature being 25°C. During ultrasonic irradiation the vessels were thermostatized.

The samples were ultrasonically irradiated at atmospheric pressure.

Erythrocyte hemolysis in an ultrasonic field can be regarded as a general model for the destructive effects of ultrasounds on most cellular suspensions [1, 2]. These effects can be simply evaluated by dosing the hemoglobin with the aid of the photocolorimetric method.

In our experiments the degree of hemolysis was determined photocolorimetrically by dosing the quantity of hemoglobin, the method utilized being the photometric method with cyanmethemoglobin adapted to our experimental conditions. Inasmuch as it is a question of low concentrations, after centrifugation of the samples treated with ultrasounds we placed 0.2 mℓ of the supernatant, instead of 0.02 mℓ, in 5 mℓ Drapkin reagent. After 30 minutes the samples were colorimetrized with the aid of an IEK electrocolorimeter, using a green filter.

Table I shows the experimental values obtained.

TABLE I. TIME NECESSARY TO OBTAIN HEMOLYSIS AS A FUNCTION OF ULTRA-/129
SONIC FIELD CONCENTRATION AND INTENSITY.

Ultrasonic Field Intensity (in W/cm^2)	Time Necessary to Obtain Hemolysis (in seconds)			
	Volumetric Concentration of Erythrocyte Suspensions			
	0.5%	1.0%	1.5%	2.0%
0.2	40	50	70	
0.4	20	30	40	
0.6	10	20	30	90
0.8	5	10	20	60
1.0		5	10	20
1.2			5	10

If the logarithmic value of the time necessary to obtain hemolysis is represented as a function of intensity for a constant value of the concentration, we obtain a straight line. Consequently, for different values of the concentration we obtain a family of straight lines with different angular coefficients. A graphic representation is shown in Fig. 1.

From the graphic representation it ensues that the straight lines which form the family in question are not parallel but have rather close angular coefficients. The mathematical expression for the straight lines obtained is

$$t = e^{k_1 c_2 + k_2 I c + k_3} \qquad (1)$$

where: t is the time necessary to obtain hemolysis, I is the ultrasonic field intensity, k_1, k_2, k_3 are constants that depend on the /130 type of suspension.

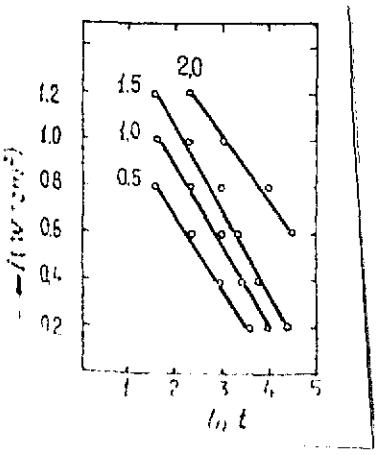


Fig. 1.

It can be seen from the mathematical formula that the irradiation time varies exponentially with the volumetric concentration of the suspension and with the ultrasonic field intensity.

The relation is valid regardless of the biological substrate because it characterizes physicochemical phenomena that take place in the system, and the constants k_1, k_2, k_3 that depend on the nature of the system characterize it implicitly from the biological point of view.

Experimental determinations have been carried out on the erythrocytes of different animals, namely: carp, frogs, turtles, chickens, rats [3, 4, 5, 6, 7]; but these constants have been numerically calculated only in the case of rat erythrocyte suspensions.

The quantities of Table I are substituted in the mathematical expression, which results in a system of equations as a function of k_1, k_2, k_3. This system is characterized by the fact that there are more equations than the number of unknowns and so it can be solved according to Bouché's theorem (from linear algebra). The rank of the matrix of the system is determined. The principal determinant is calculated according to Cramer's rule and the unknowns k_1, k_2, k_3 are determined by calculating the corresponding determinants. These values represent an optimal approximate solution because the errors remain below the limits of biological significance.

Using the data for rat erythrocytes in Table I and applying the above-described method we obtained on the basis of Eq. (1) the following values for constants k_1, k_2, k_3:

$$k_1 = 1.57$$
$$k_2 = -3.61$$
$$k_3 = 3.18$$

/131

Substituting these values in functional relation (1) in the concrete case -- that of rat erythrocyte suspension -- we obtain the following expression:

$$T = e^{1.57c^2-3.61Ic+3.18} \qquad (2)$$

This concrete mathematical relation permits us to calculate theoretically any parameter (the time necessary to obtain hemolysis, the ultrasonic field intensity, the volumetric concentration of this suspension) with a view to comparison with values determined in an experimental manner.

Thus, the relation permits evaluation of the limit of applicability of the method used in the aggregate and the lower and upper limits of the experimental parameters for any open biological system.

Summary /133

If the logarithmic value of the time necessary to obtain hemolysis is represented as a function of intensity for a constant value of the concentration, we obtain a straight line. Consequently, for different values of the concentration we obtain a family of straight lines with different angular coefficients. In clarification of the interdependence among the volumetric concentration of the suspension, the intensity of the ultrasonic field and the time necessary to obtain hemolysis, a quantitative relation was found. From the mathematical formula it ensues that ultrasonic treatment changes exponentially with the volumetric concentration of the suspension and the intensity of the ultrasonic field.

REFERENCES /131

1. Dognon, A., Les ultra-sons et leurs applications [Ultrasounds and their applications], Press Univ. de France, Paris, 1953, p. 121.

2. Dognon, A. and Y. Simonot, Strahlentherapie 89/1, 152-160 (1962).

3. Macavei, I., E. Veress, D. Ausländer, and C. Serban, Proc. X Conf. Int. Acoust. Ultrasons [Proceedings of the 10th International Ultrasound Conference], Prague, 1972, pp. 25-28.

4. Pora, E.A., Eva Veress, National Biophysics Conference, Bucharest, 25-26 May 1971.

5. Pora, E.A., Eva Veress, Session of the Academy of the Socialist Republic of Romania, Bucharest, 6-7 Dec., 1972.

6. Veress, Eva and E.A. Pora, Proc. 7th Int. Cong. on Acoust., Budapest, 1971, pp. 653-656. /132

7. Veress, Eva and J. Vincze, Proc. al VIII-lea Simpozion National de Biofizica [Proceedings of the 8th National Symposium on Biophysics], Timisoara, 1972, pp. 293-297.

8. Veress, Eva and J. Vincze, Proc. 5th Conf. on Acoustics, Budapest, 10-14 April 1973, pp. 1-6.

9. Vransky, V. and I. Zafirov, Studia Biophys.(Berlin) 2/2, 71-78 (1967).

ULTRASONIC THERAPY IN OTORHINOLARYNGOLOGY

M. Ionescu, M.D. Nicu, and Lucia Ionescu-Ghermanescu
Students' Hospital; Academy of the Romanian Socialist Republic; Polytechnic Institute, Bucharest, Romania

Constituting a promising new chapter in biophysical and medi- /135
cal research, ultrasounds are longitudinal vibrations which are propagated from one portion to another of a material medium (whose particles are thereby subjected to oscillations about their position of equilibrium) and which have a frequency field situated beyond the audible spectrum (above 20,000 Hz) [7, 13, 14]. The rate of propagation of ultrasounds differs for different media: 331 m/sec in gases, 1500 m/sec in water, 5100 m/sec in metals (steel). Of the parameters that characterize the oscillating medium, let us mention: the amplitude (the maximum shift undergone by a particle of the vibrating medium along the axis of propagation of the ultrasounds); the pressure amplitude (the maximum change in pressure along the axis of propagation of the ultrasounds) and the energy contained per unit volume $U = 2\pi^2 a_0^2 \rho/T$, in which a_0 equals the amplitude; ρ equals the density of the vibrating medium and T equals the period; the power received per unit area is $W = 2\pi^2 a_0^2 \rho v/T$. The properties of ultrasounds, among which we might mention the acoustic impedance and the absorption but, especially, their weak propagation in air (high absorption coefficient), account for their widespread utilization in medical practice. Interposed between ultrasound generator and human body is a substance that is a "good conductor," such as water, glycerine, vaseline, paraffin oil or an aqueous gel. For example, the penetration of ultrasounds into biological tissues is 60 cm for a frequency of 1 MHz and 15 cm for a frequency of 4 MHz. Their diagnostic utilization is based on their different rates of propagation in different media owing to the reflection and refraction of ultrasounds. At the high frequencies utilized in medicine, ultrasounds are propagated in a straight line; in case of their diagnostic utilization, the ultrasound bundle has got to strike the interface of two media perpendicularly so that the fraction reflected will return to the transmitter (echographic case A). Let us recall in brief the biological effects of ultrasounds. Cavitation is the appearance of small gas bubbles in the media traversed by ultrasounds with a given amplitude. To this phenomenon are due most of the chemical and biological actions of ultrasounds: oxidation reactions, protein denaturation, depolymerizations, forma- /136
tion of microscopic eddies in liquids. Cavitation also causes formation of emulsions and coalescence of solid particles as a result of the force of attraction set up between them by the ultrasonic field. On the biological level, cavitation causes changes in cell structures and their organelles (chromosomal changes) and,

at very high energies, tissue changes like edemas, hemorrhagic suffusions and even necrotic foci. Thermal effects appear as a result of the transformation into heat of the ultrasonic energy absorbed at the interface of two media in which the rates of propagation of these vibrations are different: the particle motions produced by the passage of an ultrasonic wave cause heating through friction (for example, incident to passage from muscle to bone). The caloric threshold is situated at weak intensities, the painful intensity being on the order of 2 W/cm^2 [8]. Some authors there are who attribute the therapeutic effect of ultrasounds mainly to the heat evolved in tissues. Sonoluminescence, or the generation of electromagnetic radiations of the visible spectrum in tissues under the action of ultrasounds, plays a role whose biological action is too little known. Owing to these effects, the application of ultrasounds in medicine is undergoing continuous development. Three domains are involved: diagnostics, therapy and, subsidiarily, the method of cleaning surgical instruments [7, 9, 10, 12, 15, 16, 18].

1. Diagnostic applications of ultrasounds would have favorable consequences: the absence of harmfulness to the organism (owing to their short-lived application), their great penetrability (there exist practically no bodies that are impenetrable to ultrasounds), the ability of an ultrasound beam to determine the location and establish the size, shape and density of pathological tissues, the possibility of examining incomplete organs or very small objects, the absence of any special means of preparing patients or contrast substances, as is the case for other means of investigation (x-rays) [15]. Diagnostic methods based on recuperation of fragments of the ultrasonic beam reflected from the interface of two organs with different ultrasonic impedances (so-called ultrasonic echoes), also called echographic methods, are the only ones in use at the present time [7]. Echography A uses a discontinuously operating transmitter-receiver, which receives during its transmitting pauses the echoes formed by the reflection of ultrasounds from different interfaces, which are then transformed into electrical pulses and projected onto the screen of a cathode-ray oscilloscope. An input echo, an output echo and one or more intermediate echoes are noted. Echography B is based on /137
the same principle as echography A, but owing to the possibility of shifting the probe, it brings about true sections or "ultrasonic tomographs." The information appears on the cathode-ray oscilloscope screen in the form of a sectional image in which the principal structures of the traversed organs can be recognized. Echography TM (time-motion) is applied to organs in motion (such as the heart), in which the echoes obtained from two different organs, one of them fixed and the other mobile, are treated differently from the electronic point of view: the fixed echo gives rise on the oscilloscope screen to a linear tracing, while that from the mobile organ gives rise to a sinusoidal tracing synchronous with its motion. Doppler echography uses an emitter

and a receiver and is based on the principle of emission of an audible sound signal at the moment of reception of the fraction of reflected ultrasounds that has another frequency as compared with the initial fraction (Doppler effect). In medical practice these diagnostic methods are finding an ever wider application. Thus, in neuropathology echo encephalography is employed which by means of echography A permits the bringing to light of the intracerebral hematomas, both epidural and subdural, of the ventricular ectasias due to cerebral atrophy, hydrocephalus and tumors of the posterior fossa. Echography B permits intracerebral tumoral processes to be studied. In obstetrics and and gynecology echography A is utilized in fetal cephalometry with a precision of up to 2 mm, in measurement of the promontoretropubian conjugate diameter, in diagnosis of general pregnancies, in study of adnexal tumors, with differentiation of cystic tumors from fibromatous tumors. Echography B, in addition, permits localization of the position of the placenta with a precision of 97%, detection of fetal malformations (hydrocephalus, anencephaly), and echography TM permits study of the beating of the fetal heart. Doppler echography permits analysis of fetal cardiac noises before they become stethacoustically audible, as well as study of placental circulation. In internal pathology, ultrasonic hepatography obtained by means of echography B identifies the hepatic volume, gives information about the cystic or compact character of intrahepatic formations, permits differentiation of the normal liver from the hepatic or cirrhotic liver, in time, permitting determination of the evolution of a hepatitis. In mammary pathology, ultrasonic echography constitutes a useful complement to infrared thermography, rendering precise the cystic or solid nature of tumors. In ophthalmology echography A and B are utilized in diagnosis of detachments of the retina, /138 ruptures of the sclerotic and intraocular tumors. In addition to these principal indications for diagnostic purposes, ultrasounds are also used in ferreting out ureteropelvic and biliary calculi, in study of cardiac motions (echography TM), in study of the wall of the thoracic and abdominal aorta and of its lumen, bringing out aneurismal ectasias and atheromatous stenoses, in study of the skeleton and of foreign bodies in the organism.

2. Therapeutic application of ultrasounds employs a usually continuously operating emitter the intensity of whose beam can be easily adjusted from 0.5 to 3 W/cm^2 (up to 15 W/cm^2 for only some applications); the frequencies utilized being 0.5-2 MHz. In local application a conducting substance is interposed between probe and integument or irradiation is carried out in water (when the segment in question can be immersed). The duration of a session is 10-15 minutes, in all 10-12 sessions, with a frequency of three per week [8, 9, 10, 12]. Indications for treatment with ultrasounds. Treatment for analgesic purposes is indicated in cervicobrachial, facial, intercostal and sciatic neuralgias, as well as neuralgia of Arnold's nerve, in amputation neuromas and painful disabilities,

in dry traumatisms (fractures, sprains, hydrarthrosis), epicondilitis, spondilitis, coxarthritis, calcarine spurs, myalgias, torticollis,lumbago [7, 8]. Treatment for antispasmodic purposes in bronchospasm, brochitic asthma (in application on the stelate ganglion and the thoracic sympaticus, using either the anterior path or the posterior laterovertebral path [15]), in spasms of the digestive apparatus, in vascular spasms. Treatment for anti-inflammatory purposes in the initial phase of acute inflammatory processes, such as: dental gingivitis and perialveolitis, tendonitis and tenosinovitis, furuncle, phlegmon or panaritium in the uncollected stage, suprainfected trophic ulcers. Treatment for fibrolytic purposes in cellulitis, trophic ulcers, retractile cicatrices or cheloids, eczematized lesions (with or without pruritis), in chronic posttraumatic edemas.

Contraindications for ultrasonic therapy are represented by particularly sensitive anatomic regions such as the heart, aorta, spinal marrow, encephalon, and testicle or certain affections whose evolution is clearly aggravated: tuberculosis, malignant tumors, syndromes of capillary fragility. Ultrasonic therapy is also contraindicated for pregnant women and children in the case of the connecting cartilages of the limbs (it can perturb or /139 arrest growth).

3. Use of ultrasounds for the cleaning of surgical instruments requires a 1-KW generator at a frequency of 25 KHz placed at the bottom of a vessel filled with detergent solution. Under the influence of the friction produced by ultrasonic vibrations, the c l e a n i n g substance penetrates into cracks, fissures and articulations of the instruments, removing deposits of blood, salts, oils and greases in a maximum of 3 minutes. Cleaning of the instruments is terminated by washing them in a second vessel.

Particular Applications of Ultrasounds in Otorhinolaryngology

For diagnostic purposes, the application of ultrasounds in otorhinolaryngology is aimed at exploration of the paranasal cavities (especially the maxillary sinus) and the morphofunctional state of the middle ear (presence or absence of liquid); as well as the state of the tympanum in relation to the medial wall of the box (existence or nonexistence of retraction of the tympanum) [1, 11]. For this purpose a 3-mm diameter ultrasound generator is introduced into the external auditory canal, which is filled beforehand with liquid (water), using the method of echography A. On the cathode-ray oscilloscope screen a separate echo is obtained for each plane encountered by the ultrasonic wave. For therapeutic purposes the utilization of ultrasounds in otorhinolaryngology has the following indications: a) In inflammatory affections of the integuments of the face (folliculosis, lymphangitis), with antiphlogistic action similar to that of roentgenotherapy;

b) in cranial and craniofacial pains (painful facial neuralgias caused by vacuum of the sinus): c) in pharyngeal paresthesias; d) in rhinosinusitis: in spasmodic coryza, by directing the ultrasonic beam onto the sphenopalatine ganglion (using an intensity of 1.5 W/cm^2) and maxillary sinusites (with an intensity of 0.7 W/cm^2), either alone or combined with aerosols according to the method of Flottes and Riu [7], which permits easier absorption of aerosol drops, concomitantly with the action of mechanical vibrations with an antiphlogistic effect. In connection with these, let us mention the use of ultrasounds as a means of pulverization of medicinal solutions into microscopic aerosol particles (in apparatuses of the TUR 1 and 2 types), with very deep penetration into the respiratory passages. Employment of this aerosolization method in a time interval of over 5 years on 2500 patients convinced us of its superiority over the classical method with compressor. Recently employed with success /140 is so-called phonophoresis, a method of administering drugs with the aid of ultrasounds [17]. A pomade (hydrocortisone 5 g, lanolin and vaseline aa 25 g) is applied onto the integument with a wooden spatula and then the ultrasound generator is brought into contact (using an intensity of 0.2-0.6 W/cm^2, with continuous or discontinuous emission): e) in otology, ultrasound therapy has been applied in progressive chronic deafnesses of the otosclerosis type, in pathological acousmas and in Ménière's disease [13]. In otosclerosis, ultrasonic therapy applied to the tragus or mastoid has been practiced in Romania, too [9], with good initial results in a significant percentage of cases (over 60%). Advances in surgery have eliminated ultrasonic therapy from this affection at the present time. In Ménière's disease, ultrasonic therapy has recently been undergoing considerable development. The doses utilized correspond to a frequency of 1000 Hz and an intensity of 1-1.5 W/cm^2. The ultrasonic beam is propagated axially to the point of application, diffusing laterally relatively slightly and being rapidly absorbed by the media through which it passes. In order to discuss their mechanism of action in this affection, let us recall that ultrasounds rapidly produce in the nervous system a phenomenon of imbibition and degeneration, involving in particular cellular elements, the neurosensorial epithelium being especially sensitive [2]. In Ménière's disease, ultrasounds are thought to work by means of two mechanisms [5]: through destruction of the neuroepithelial elements of the ampullary crests and the otolithic maculae, suppressing the ability of the vestibular receptors to perceive oscillations of the head, hence causing a true intracranial section of the vestibular nerve; through action on hydrolabyrinth by virtue of the hyperemic and vasodilative action of ultrasounds, fostering resorption of excessive endolymphatic liquid, or braking its excessive production. The ultrasound generators employed in therapy of Ménière's disease or of the Arslan, Douglas Gordon, Anell James, and Sjöberg type, or, more recently, the Australian type, which appears to be the easiest to handle. The postulates of this therapy as established by

Arslan [3, 4] are as follows: the ultrasounds must be directed toward the external semicircular canal; the apparatus must have a sufficiently long and narrow stem (8 cm in length and 0.5 cm in diameter) to ensure powerful emission and a concentrated beam; /141
the ultrasounds must be emitted only from the extremity of the stem in order to prevent lateral irradiation, which would damage the facial nerve (the complication most to be feared in the case of this treatment); the ultrasonic bundle must be small, condensed and not exceed 2 cm in depth. The principal indication is ultrasonic destruction of the labyrinth in patients with Ménière's disease who still have good hearing. In practice, a mastoidal trepanation is effected with exposure of the lateral semicircular canal, without narrowing of the posterior wall of the canal. The stem of the ultrasound generator is applied to the canal's bony compact and is so directed that the beam will be prevented from emerging from the vestibule and damaging the facial nerve (the probe is directed downwards, forwards and medially). During irradition the vestibular response is controlled by keeping track of nystagmus. This occurs 30-60 seconds after the start of irradiation, is of the irritative type (strikes at the irradiated part), variable amplitude (degree II or III) and persists for 7-10 minutes. At the moment when it stops, Arslen recommends that the direction of the probe be changed toward the vertical semicircular canals, at which moment a new irritative nystagmus occurs, with a duration of 5-10 minutes, after the cessation of which a new application is effected at the level of the external semicircular canal and, in the event of reoccurrence of irritative nystagmus, irradiation is continued until its disappearance, followed by a new application at the level of the vertical canals. After 25-30 minutes of irradiation, nystagmus of the irritative type disappears and is replaced by a nystagmus of the paralytic, destructive type, which strikes at the opposite, nonirradiated ear. Irradiation intensity is 9-10 W/cm^2 or 12-14 W/cm^2 (it is never recommended to exceed these intensities) for a duration of 25-30 minutes at a frequency of 800,000 Hz. The results are spectacular, the method having the advantage of eliminating vertiginous crises and keeping the auditory function intact at the level at which it was found at the start of treatment.
In recent years irradiation of the posterior labyrinth at the level of the fenestra rotunda [6, 14] has been used more and more, a method which also yields better results in the treatment of acousmas, requiring as it does less energy and a shorter duration. Unfortunately, the risk of complications (especially involving the facial nerve) is much greater, a fact that requires a special precision in applying this method. /142

Conclusions

1. The mechanism of the biological action of ultrasounds is mainly based on the phenomenon of cavitation and, subsidiarily, thermal and sonoluminescent effects.

2. Diagnostic utilization of ultrasounds is based on their penetrability and on the existence of echoes resulting from their reflections at the interface of media with different acoustic impedances, echoes that underlie echographic methods.

3. Therapeutic application of ultrasounds is based on their biological actions. Ultrasonic phonophoresis (the transcutaneous conveyance of active medicinal substances by means of ultrasounds) constitutes a new and valuable therapeutic acquisition.

4. Utilization of ultrasounds in ORL therapy is dominated by selective destruction of the vestibular receptors in Ménière's disease with preserved hearing, with results that are superior to those of other methods of labyrinthine destruction.

5. The results of the diagnostic and therapeutic application in medicine in general and in otorhinolaryngology in particular justify the necessity of generalizing them in medical practice in Romania, an action which dictates the acquisition of the appropriate apparatus and instruction of medical personnel in the basic notions involved in their correct utilization.

Summary /143

After a brief discussion of the physical properties and biological effects of ultrasounds, the authors describe their utilization in medicine in general and in otorhinolaryngology in particular. The authors pass in review the most modern diagnostic methods (including the technique of interpreting them), as well as the application of ultrasounds in therapy, with emphasis on methodological details (apparatus, application paths, dosage) in Ménière's disease with preserved hearing, which is the indication that dominates their utilization in otorhinolaryngology. In conclusion, the authors underline the great value of ultrasounds in medical practice, a fact that justifies the acquisition of apparatus and instruction of medical personnel for the purpose of utilizing them correctly.

REFERENCES /142

1. Abramson, D.H. et al., Arch. of Otolaryng. 2, 146-150 (1972).
2. Angell James et al., Med. Biol. Engineering 5, 474-481(1970)
3. Arslan, M., Muench. Med. Wschr. 26, 1315-1318 (1965).
4. Arslan, M. et al., Minerva Medica 72, 2989-2995 (1965).
5. Aubry, M. and P. Pialoux, Progrès en ORL [Advances in ORL], Ed. Flammarion, Paris, 1968.
6. Basek, M., Laryngoscope 70, 768-776 (1970).
7. Bourjat, P. and M. Gautherie, France Méd. 7, 329-336 (1968).
8. Buchan, J.F., The Practitioner 1243, 319-326 (1972).
9. Craciun, C. et al., Clujul Medical 1, 71-76 (1971).
10. Friedland, F., JAMA 163/10, 799-803 (1957).
11. Kitamura, T., Eye, Ear, Nose, Throat 48, 329-337 (1969).
12. Perdrisot, M.A., Algérie Méd. 2, 169-176 (1953).
13. Portmann, G. et al., L'ultrasonothérapie en ORL [Ultrasonic therapy in ORL], L. Arnette, 1954.
14. Salva, J. et al., Acta Otorinolar. Ib. Amer. 3, 295-309 (1970).
15. Safiolina, N., Sovetskaya Meditsina 1, 32-38 (1970).
16. Scelsi, B., Minerva Medica 28, 942-945 (1955).
17. Speranski, A.P., Bull. Inform. CDM 10, 1388-1395 (1968).
18. Whyte, L., Elektromedizin und ihre Grenzebiete [Electromedicine and its boundary regions], Vol. 4, 1965, pp. 213-216.

ULTRASONIC THERAPY IN MEDICAL RECOVERY FROM DEGENERATIVE RHEUMATIC AFFECTIONS OF THE VERTEBRAL COLUMN

C. Craciun, E. Morariu, P. Pusca, and V. Mares
Cluj Balneology Clinic

In degenerative affections of the vertebral column, ultrasonic therapy yields favorable results, as emerges from the studies of a number of authors: Denier [6], Müller [11], Hintzelmann [8]. /145

In the Balneology Clinic of Cluj, most studies with regard to the practical and theoretical position of ultrasonic therapy as part of recovery therapy by physical means have involved patients with degenerative affections of the vertebral column. It has been found that the therapeutic results depend on: the evolutive phase of the disease, the existing morphological and functional substrate, but also the manner of administration (doses, rhythm, irradiation duration), as well as the fitting in of ultrasonic therapy into the aggregate of other procedures.

In the present study we proposed to confirm the utility of small doses, using a very sensitive test (perfusion with angiotensin), as well as to study some changes in the functional state of the large nervous and humoral control mechanisms (electroencephalographic changes, as well as changes in pituitary-adrenocortical reactivity) caused by ultrasonic therapy in degenerative rheumatism of the vertebral column.

Method and Materials

Thirty-six patients with degenerative affections of the vertebral column were irradiated with ultrasounds from a VEM apparatus (Transformatoren und Röntgen-werk, Dresden) at a frequency of 800,000 Hz, with a 10-cm^2 transmitter, at 2-day intervals, in paravertebral fields, in a series of 10-12 sessions, with intensities of 0.5 W/cm^2 in the treatments and of 2 W/cm^2 in one of the groups subjected to the test with angiotensin. /146

In order to confirm the utility of small doses of ultrasounds, we employed the test of perfusion with angiotensin II (Hypertensin-Ciba) conducted in accordance with the directions of Kaplan and Silah [9]. It consisted in determination of the dose of angiotensin (expressed in mg // kg body weight / min) capable of causing an increase in diastolic pressure by 20 mmHg. We recorded the test values before, during and after treatment.

The electroencephalograms of ten patients were recorded by means of an "Alvar" apparatus with 20 leads.

In order to correlate them with a possible stage of clinical exacerbation, as well as with final therapeutic efficacy, some endocrine effects of reduced doses of ultrasounds were investigated by checking the changes in pituitary-adrenocortical activity [10] in terms of urinary 17-ketosteroids (Drekter method) and urinary 17-ketogens (Norimbersky method).

Results and Discussion

Table 1 shows the values of the angiotensin perfusion test calculated in mg / kg body weight / min. The changes observed show a number of characteristics connected with the dose employed for irradiation.

Table 2 shows the statistico-mathematical processing. Application of Student's significance test discloses that there are significant differences between the values obtained in the middle of treatment (designated by 4) and those obtained at the end of treatment (designated by 6) but only in the group irradiated with small doses (0.5 W/cm^2). Thus, $t_{4,6} = 2.33$; hence $0.05 < p < 0.02$. /147
For the rest, the differences are insignificant.

Analysis of the results shown in Table 1 reveals two groups of reactions as a function of the dose (0.5 W/cm^2 and 2 W/cm^2).

In the group treated with small doses (0.5 W/cm^2) a clear tendency toward normalization of test values can be observed. For the same group, around the 5th session a deviation can be observed in the opposite direction, so that normalization is subsequently recorded at the end of the series. Sometimes this two-phase reaction has as its clinical correspondent an accentuation of the symptomatology.

On the other hand, the response to the angiotensin perfusion test when using large ultrasonic doses (2 W/cm^2) shows a vasoconstrictive reaction with prolonged inhibition of the vasomotory centers. This is a confirmation of our previous observations [2], when utilization of large doses led to exaggerated vasoconstriction associated with disappearance or reduction in amplitude of reflexes to cold and reduction in the centrally sensitizing effect of adrenalin. Much to be emphasized is the fact that utilization of large doses (2-2.5 W/cm^2) was advocated on the basis of the then-prevailing views regarding the predominantly localized action of ultrasounds.

Utilization of small doses (below 1 W/cm^2) is also based on the conception of a general action of these irradiations. This

TABLE 1.

Exp. No.	First and Last Names and Ultrasonic Dose	Start of Ultrasonic Treatment. Kaplan-Silah Test (mg/ /kg body weight/min)		Middle of Ultrasonic Treatment. Kaplan-Silah Test (mg/kg body weight/min)		End of Ultrasonic Treatment. Kaplan-Silah Test	
		Before 1st Irradiation	After 1st Irradiation	Before 5th Irradiation	After 5th Irradiation	Before 10th Irradiation	After 10th Irradiation
1	E.S. 0.5 W/cm^2	7.626	9.868	8.972	11.215	7.626	8.075
2	C.G. 0.5 W/cm^2	6.659	7.966	7.081	8.852	8.852	7.*82
3	C.P. 0.5 W/cm^2	6.326	9.069	10.326	11.802	8.638	7.376
4	C.S. 0.5 W/cm^2	8.000	5.600	-	-	4.800	4.600
5	K.G. 0.5 W/cm^2	5.690	8.484	6.250	7.040	6.010	5.215
6	V.V. 2 W/cm^2	7.519	7.379	4.151	3.690	6.457	4.812
7	C.S. 2 W/cm^2	8.432	7.905	9.486	8.432	7.454	7.578
8	W.T. 2 W/cm^2	8.075	8.970	8.075	6.280	5.383	4.486

*[Numeral illegible in original text.]

TABLE 2.

	Start of Ultrasonic Treatment		Middle of Ultrasonic Treatment		End of Ultrasonic Treatment	
	Before 1st Irradiation 1.	5 min After 1st Irradiation 2.	Before 5th Session 3.	5 min After 5th Session 4.	Before 10th Irradiation 5.	5 min After 10th Irradiation 6.
0.5 W/cm^2						
n	5	5	5	5	5	5
$\bar{x}$	7.636	8.502	8.157	8.727	6.786	6.470
σ	1.743	1.783	1.841	2.199	1.543	1.487
e	0.779	0.793	0.920	1.100	0.691	0.665
2 W/cm^2	7.	8.	9.	10.	11.	12.
n	3	3	3	3	3	3
$\bar{x}$	7.962	8.085	7.237	6.134	6.431	5.482
σ	0.635	0.810	1.764	1.374	1.036	1.634
e	0.309	0.468	1.596	1.371	0.598	0.944

n = Number of subjects
$\bar{x}$ = Mean
σ = Standard deviation
e = Error

therapy leads to extensive reflexes with their point of departure in the irradiated tissues, reflexes which modify the functional state of some large general mechanisms that exert control over important adaptive functions: vasomotricity, tissue trophicity, reactivity in the presence of inflammatory processes, etc.

We were also able to bring to light this influence of small doses on "general reactivity" by functional changes in the pituitary-adrenocortical axis, by changes in the bioelectric electroencephalographic tracings.

The effects of ultrasonic treatment on the electroencephalogram are shown in Table 3.

The painful contraction of the paravertebral muscles expresses the hyperexcitability of the interoreceptors of the vertebral column or of the organs of that region, connected with, among other factors, a neurosis. The presence on the electroencephalogram of overturned tracings, as well as of rapid activity in a large percentage in the posterior regions and slow waves overturned anteriorly, argues in favor of a neurosis, as well as in favor of the coexistence of chronic circulation disorders. /148

Because there can be no question of an etiopathogenic treatment in degenerative rheumatic affections, but only of a more general physiopathogenic treatment, with central action on the nervous system, it must be agreed that ultrasonic therapy be directed in the first place to these centers and in the second place to the local neuromuscular symptomatology. Disturbance of the central nervous system and loss of control over the higher neurovegetative centers of the zona reticularis can generate and maintain degenerative and inflammatory processes through disorders of the muscular tonus, as well as through vasomotory and consecutive metabolic disorders. Analysis of the electroencephalographic data inclines us to assert that ultrasonic irradiation in small doses is connected with a change in tonus of the reticular substance of the cerebral trunk and with the production of an equilibration of fundamental processes.

Investigating pituitary-adrenocortical reactivity to small ultrasonic doses in a previous study [2], we utilized the indirect method of variability of fundamental eosilophilia. The results disclosed evolution toward eosinopenia in most of the patients, as well as the two-phase character of this evolution.

Table 4 shows the values for elimination of urinary 17-ketosteroids and 17-ketogens.

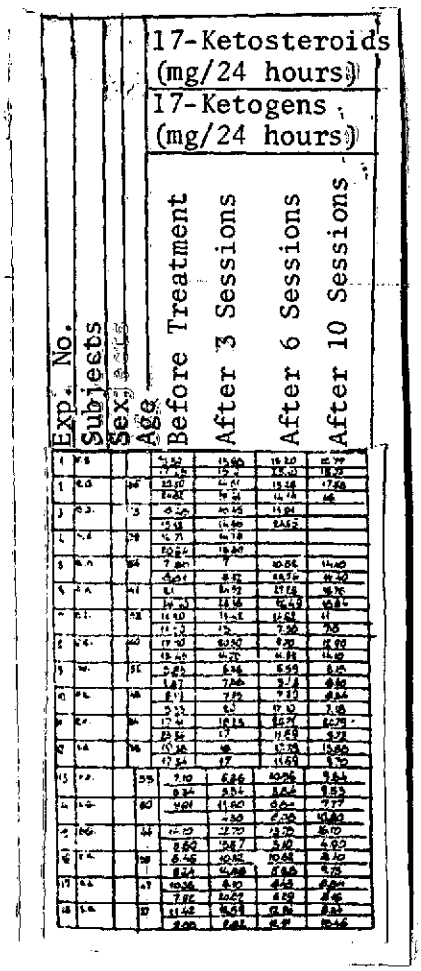
Conspicuous in this table is the obvious polymorphism of the type of reaction. In cases with a positive reaction, two groups can be distinguished, namely: those who had had a normal initial /149

TABLE 3. BEHAVIOR OF DIFFERENT ELECTROENCEPHALOGRAPHIC WAVES IN THE COURSE OF ULTRASONIC TREATMENT IN DEGENERATIVE RHEUMATISM OF THE VERTEBRAL COLUMN.

				Before Treatment	After 5 Sessions	After 20 Sessions
Spontaneous Activity	Amplitude		up to 15 μV	6 cases	5	1 case
			" " 30 μV	4 "	1	5 "
			" " 50 μV	- "	3	3 "
	Posterior	Wave	8-9 c/s	2	1	-
			9-10 c/s	3	2	4
			10-11 c/s	1	3	2
		Rapid Activity	Rapid	2	3	-
			Rapid+0	2	1	3
		Slow	[illeg] 0	-	-	-
	Anterior		Rapid	2	3	3
			Rapid + slow waves	4	3	2
			Slow, overturned	3	4	2
			[illeg]	-	-	1
			Statico-electric	1	-	-
[Illeg]	Causes no change			4	1	1
	Amplitude		up to 15 μV	1	2	-
			" " 30 μV	2	4	2
			50 μV or over	2	2	5
	[illeg] persists		Irregular	2	5	1
	Disorganized tracing, Δ		In tracing	3	7	6
	Discharges		B	1	3	4
			Δ	2	1	1
			[illeg]	-	-	2
			Persists over 1 min	1	2	4

level of 17-ketogenation and those with reduced initial values (about 5 mg/24 hours). In these latter patients a progressive tendency toward normalization of the elimination values can be observed (6.5-10 mg/24 hours). In the others -- as compared with the normal initial level -- in the course of treatment a considerable increase occurs in 17-ketogen elimination (on an average 11 mg). In this group of patients, with positive pituitary-adrenocortical reactivity, therapeutic results were good and very good in ten patients and mediocre in one patient (K.G.) with a reduced initial elimination level and the most advanced age of the entire group (60 years).

TABLE 4.



Reproduced from best available copy.

The shape of the corticoid elimination curve for another group of patients had an areactive or hyperactive character.

The last group of four patients was peculiar in showing increased 17-ketogen and 17-ketosteroid elimination (20-26 mg/24 hours before treatment).

In the course of treatment these results become normalized. Clinically, the best results are obtained, the patients leaving the department with the entry "very improved," though the general appearance of the curve could have been considered "areactive."

This phenomenon we interpret as follows: during the very intensely painful period that preceded ultrasonic therapy, it represented a complex stress factor that caused an increase in functional pituitary-adrenocortical tonus. By removing the stress factor, the rather prompt analgetic effect of the general and local action of ultrasounds caused the pain and the hypertonia of the glucocorticoid control system to cease, the eliminations returning to within normal limits.

It follows that the efficacy of ultrasonic therapy is not directly dependent on the secretory stimulation amplitude of the adrenal cortex. The mechanisms of action turn out to be much more complex, and therefore the changes in corticoid elimination are only a sensitive indication of neuro-pituitary-adrenocortical activity. /150

Summary /151

By irradiating with ultrasounds 36 patients having degenerative rheumatic disease of the spine we intended, in the first place, to confirm the utility of small doses by means of a more sensitive test (perfusion with angiotensin) and, in the second place, to study some changes in the functional state of the large nervous and humoral mechanisms by means of adrenocortical reactivity.

Our research disclosed a tendency toward normalization of the value of the applied tests and also the fact that the efficacy of ultrasonic therapy in small doses is not directly dependent on the secretory stimulation amplitude of the adrenal cortex. A phasic evolution of general reactions to irradiations applied in successive treatments is found. In degenerative rheumatic diseases of the spine ultrasonic therapy represents a powerful decontracting and analgetic means. Being an easily tolerated and very efficient treatment, its more extended use can be recommended in these diseases.

REFERENCES /150

1. Baciu, I., C. Craciun, and T. Baciu, Articole si lucari stiintifice [Scientific articles and studies], Ed. I.M.F., Cluj, 1958, p. 109.

2. Craciun, Utilizarea ultrasunetului in terapie. (Observatiuni asupra dozelor mici) [Utilization of ultrasounds in therapy. (Observations on small doses)], Dissertation, Cluj, 1958.

3. Craciun, C., E. Morariu, and C. Dudea, Stud. si cercet. balneo. si fizio. [Balneological and physiological studies and research], Vol. VII, Bucharest, 1965, p. 133.

4. Craciun, C., E. Morariu, C. Dudea, and A. Mircea, Clujul medical, 133 (1965).

5. Craciun, C., E. Morariu, C. Dudea, V. Mares, N. Opreanu, and M. Granescu, Stud. si cercet. balneo. si fizio. [Balneological and physiological studies and research], Vol. IX, Bucharest, 1967, p. 422.

6. Denier, A., Presse médicale 5, 22 (1946).

7. Hintzelmann, U., U.E. Med. 5, 38 (1952).

8. Hintzelmann, U., Schweiz. Med. Wschr. 79, 759 (1949).

9. Kaplan, N.M. and J.G. Silah, New Engl. J. Med. 271, 436 (1964).

10. Morariu, E., C. Craciun, M. Risca, I. Baciu, R. Dascalau, Arch. f. Phys. Ther. 1, 67 (1969).

11. Müller, J., Ultrakus. Mitt. 3 (1949).

THE RELATIONSHIP BETWEEN TONE AND SPEECH PERCEPTION IN CASES OF NOISE-INDUCED HEARING LOSS

G. Tymnik and H. Beyer
Ear, Nose and Throat Clinic of the Magdeburg
Medical Academy, GDR

In the interest of the individual being evaluated, it is /153
necessary to strive for reproducibility in the results and thus a high level of uniformity in the determination of percentage hearing loss and of the extent of physical injury calculated from this when noise-induced hearing impairment is evaluated. In addition to a precise knowledge of the reliability and information content of the various methods of testing hearing, however, this also requires knowledge of the relationship between the different computational methods for determining percentage hearing loss.

In the German-speaking area, the speech audiogram, with Boenninghaus and Röser's computational table [1] and the pure-tone audiogram, with Fowler and Sabine's table [2], are primarily used in determining quantitative hearing loss.

For our comparative calculations, we evaluated the results from 101 tone-threshold and speech audiograms of subjects with noise-induced hearing loss, using the method described. Thus 202 ears damaged by noise were evaluated. The measurements were made with the MA 20 - MA 40 audiometer set produced by Clamann & Grahnert, Dresden. The pure-tone threshold on the MA 20 audiometer was calibrated in accordance with ISO R 389. The MA 40 supplementary speech instrument had a coupling acoustic pressure level of +107 dB at a frequency of 1000 Hz when the intensity regulator on the MA 20 audiometer was set at 100 dB. Since 50% number comprehension is achieved at 15 dB with the MA 40 supplementary speech instrument if, upon calibration, the coupling acoustic pressure level is +109 dB at a 100-dB regulator setting /154
on the MA 20 audiometer, according to Sauer [3], our subjects were given speech which was too "soft" by 2 dB. The differences which we found between the values calculated from the tone-threshold and speech audiograms are therefore more likely to be too small than too large.

In comparing the two methods, we expected a nonlinear relationship. Evaluation yielded the following lines of regression, however: For the Fowler/Sabine method's relationship to speech audiometry, we calculated $Y = 1.38\,x - 41.4$ with a standard deviation of $s = \pm 11.6\%$. For the relationship of speech audiometry to the Fowler/Sabine method, we obtained $X = 0.7y + 28.0$ with a standard deviation of $s = \pm 13.0\%$.

We determined the mean significant deviation between the two methods to be 20.7%. Standard deviation was ±15.6%. In this comparative calculation we also divided the subjects into three age groups. Group I included subjects up to 40 years of age (n = 42); group II, subjects between 41 and 55 (n = 78); and group III, subjects whose ages were greater than 55 (n = 82). We found here that the results of the computational methods described converge with advancing age. Whereas the differences were 24.2% in age group I and 22.7% in group II, it was only 16.8% in age group III. This distinct drop in the difference between the results of the two methods can be explained not so much as an aging effect on discrimination capacity but rather the manifestation of greater truncation of speech frequencies in prolonged work associated with noise. These conditions were elucidated by the formation of five hearing-loss classes in each of the three age groups. In making the subdivisions into the various hearing-loss classes, we were guided by the frequency range of normal speech. It is known that primary verbal comprehension is made possible by the first two formant groups of the vowels and the sound patterns of the consonants in the middle frequency range of 500 to 2000 Hz. Taking these aspects into consideration, we made comparative calculations in the following five hearing-loss classes: /155

Hearing-loss class 1
Curve falls within range between 3000 Hz/30 dB and normal hearing.

Hearing-loss class 2.
Curve falls in range between class 1 and 2000 Hz/40 dB.

Hearing-loss class 3.
Curve between class 2 and 1000 Hz/40 dB.

Hearing-loss class 4.
Curve in low-frequency range, above 40 dB; beyond 1000 Hz, below 40 dB.

Hearing-loss class 5.
Curve below 40 dB at all frequencies.

The number of ears studied (n), the mean deviations in the computed results (d) and the associated standard deviations (±s) in the three age groups (I-III) and in the five hearing-loss classes are shown in Table 1.

Hearing-Loss Classes

	$d_1 \pm s_1$	$d_2 \pm s_2$	$d_3 \pm s_3$	$d_4 \pm s_4$	$d_5 \pm s_5$
I	4,2±0,7 (n=3)	18,0±5,0 (n=14)	36,5±11,1 (n=17)	20,6±13,2 (n=4)	-
II	8,3±3,2 (n=6)	22,1±6,7 (n=18)	34,3±10,9 (n=30)	23,3±17,7 (n=8)	4,7±9,5 (n=14)
III	6,7±2,4 (n=7)	22,0±8,8 (n=12)	31,0±11,6 (n=24)	15,2±21,5 (n=9)	9,1±14,1 (n=28)

It was found here that in given hearing-loss classes, only slightly differing mean deviations could be observed between the calculated results obtained by the two methods in the three age groups. A striking feature is the especially large mean deviations in hearing-loss class 3, i.e. in that class in which the frequency range of the second vowel formant, particularly important for speech comprehension, is crossed differently by the threshold curves. We assume that these large deviations can be evaluated as a manifestation of autogenous hearing training which accompanies noise-induced hearing loss (as a result of the gradual dropoff in hearing). A certain balance between the two methods of calculation could be observed in hearing-loss class 5. The convergence of the results from both methods in the 5th class can certainly be explained by the fact that all frequencies are received with approximately the same strength in this hearing-loss class. /156

In order to detect a central (age-dependent) effect upon discrimination capability, we once more examined 83 persons between 64 and 87 years of age, using the same methods.

The corresponding results are shown in Table 2 (IV: old-age hearing loss, overall; V: 64-74 years; VI: 75-87 years).

Hearing-Loss Classes

	$d_1 \pm s_1$	$d_2 \pm s_2$	$d_3 \pm s_3$	$d_4 \pm s_4$	$d_5 \pm s_5$
IV	6,5±4,8 (n=62)	12,9±7,6 (n=40)	10,3±17,4 (n=35)	-0,1±11,6 (n=13)	-3,3±11,6 (n=15)
V	6,6±4,8 (n=45)	13,3±6,2 (n=20)	20,5±13,1 (n=10)	2,8±8,4 (n=6)	1,3±13,5 (n=6)
VI	6,2±4,6 (n=17)	11,4±8,7 (n=20)	6,2±18,1 (n=25)	-2,7±13,9 (n=7)	-6,3±9,8 (n=9)

In the 1st hearing-loss class, the mean deviations between subjects with old-age hearing loss and those with noise-induced hearing loss are not significant. Important speech frequencies are not affected in this class. In the 2nd class, there is already a significant difference between speech comprehension with noise-induced hearing loss and age-dependent hearing loss. This difference becomes particularly clear in the 3rd class. In /157
the group above 75 years, the calculated differences (underlined) between tone and speech audiometry are no longer significant. This same relationship likewise exists in the 4th and 5th classes among those suffering age-dependent hearing loss. The negative differences in these classes for the group beyond 75 years show that discrimination has dropped considerably relative to the tone audiogram.

If important speech frequencies are truncated, those suffering noise-induced hearing loss still have relatively good word comprehension as a result of autogenous hearing training based on a central compensatory adjustment effect. If this central compensation does not occur or if, according to Sedlacek [4], internal speech information is faulty, as can be assumed in the age group beyond 75 years, then poor word discrimination occurs.

Mathematically definable relations between tone and speech hearing can, we believe, be derived only for similar forms of hearing loss if, in addition to other factors, primary consideration is given to central disorders.

Summary /158

Percentage hearing loss was calculated for 202 noise-damaged ears from the Fowler/Sabine tone-threshold audiogram and from the Boenninghaus/Röser speech audiogram, and the figures were related to one another. Three age groups and five hearing-loss classes were formed and the Fowler/Sabine and Boenninghaus/Röser methods were compared. We found the greatest differences between the methods in the hearing-loss class in which the threshold curve passed through the frequency range of the second vowel formant. On the other hand, the results from the two methods were found to be similar in the class in which the threshold curve lies below 40 dB at all frequencies. It was also conspicuous that in given hearing-loss classes, only slightly differing mean deviations could be found between the Fowler/Sabine and Boenninghaus/Röser methods of calculation in the three age groups. The lines of regression were also calculated for the relationship between the two methods.

REFERENCES

/157

1. Boenninghaus, H.G. and D. Röser, "Percentage hearing-loss determination for speech hearing and determination of the reduction in fitness for work," Z. Laryng. Rhinol. 37, 719 (1958).

2. Fowler, E.P., P.E. Sabine, "Tentative standard procedure for evaluating the percentage loss of hearing in medico-legal cases," J. Amer. Med. Assoc. 133, 396 (1947).

3. Sauer, U., "Readoption of the Freiburg speech comprehension test in the GDR and its normal curves," Verkehrsmedizin 19, 101 (1972).

4. Sedlacek, K., "Information content of speech audiometry," Z. Laryng. Rhinol. 46, 577 (1967).

NOISE ANNOYANCE: A PSYCHOPHYSIOLOGICAL VIEW

Edith Gulian
Institute of Psychology, Romania

Though initially the problem of noise constituted the object /159
of study especially of acousticians (as regards its measurement and control) and physicians (in order to establish hearing losses), in the last 2 decades research on its effects has become an important preoccupation of psychologists. With the development of technological civilization and, implicitly, noise sources, man is being assailed more and more by a variety of sounds which often exceed the limits that are permissible from the medical point of view and thus constitute so-called sound noxa. The results of research, however, indicate that the effects of noise are not limited to the level of the ear or the nervous system, but have many consequences of a psychological order. They are studied in the laboratory as well as directly in places located near noise sources, forming a complex picture of the action of noise. More and more often we encounter in the literature articles about complex and long-lasting investigations of the effects of noise from the psychological, physiological and social point of view, investigations which are thus tending toward a systematic and many-sided understanding of man's activity under conditions of acoustic stress [1, 2].

Psychological study of the effects of noise can be broached /160
from two angles: that of the effect of noise on the level of performance and that of the psychological discomfort it produces. These two angles are complementary but do not enter into a relationship of logical implication; in other words, even in the case in which performance does not appear to suffer as a consequence of noise, a certain degree of psychological discomfort can be established. Thus, we shall discuss separately the results of studies in these two directions.

When we broach the problem of the influence of noise on performance, we must take into consideration in the first place the complexity and multiplicity of the factors that define noise and the activities that are performed (Fig. 1). Thus, noise is characterized by its intensity, frequency (which can be stable or /161
variable), type (continuous or intermittent), nature (industrial, aeronautical, etc.), etc. The activity (or the laboratory tests that simulate different activities) is characterized in its turn by its duration, complexity and nature, as well as by the organs stressed, etc. But between these independent variables and performance or efficiency, which constitutes the final result (dependent variable) is interposed the man (the intermediate variable) who is carrying out this activity under the given conditions of noise. Consequently, his performance will be dependent

Independent Variables | Intermediate Variables | Dependent Variables

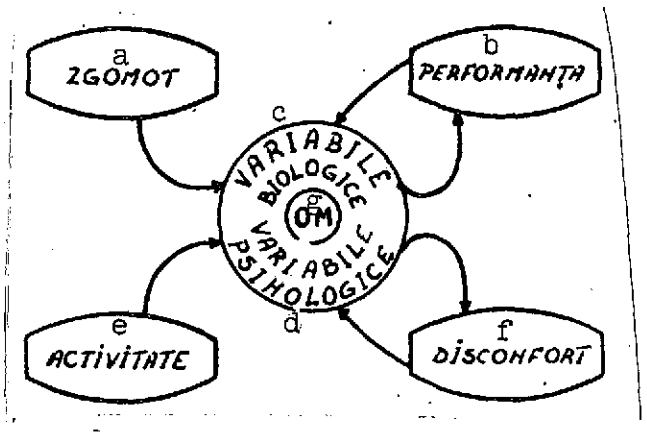


Fig. 1.

Key: a. Noise
b. Performance
c. Biological variables
d. Psychological variables
e. Activity
f. Discomfort
g. Man

on biological characteristics (general state of health, state of the auditory system, etc.), but also on psychological characteristics (characteristic features of auditory perception, motivation, attitude, familiarity with the activity in progress and with the noise, etc.). Finally, it should be noted that the level of performance (its success or failure) is not only the resultant of the enumerated factors, but will in turn influence the biopsychological variables through feedback. It will be obvious that at the same time it will act on the psychic discomfort (the other dependent variable), which will in general be lower in the case of a good performance than in the case of a poor one.

In view of the multiplicity of factors involved in the manner and degree to which the level of performance is influenced by noise, not surprising is the fact that the results of experimental studies are contradictory, some authors bringing to light harmful effects and others, positive effects or the absence of any effect, without the possibility of discerning a preponderance of negative results.

Here we cannot enter into the details, but we must emphasize that prolonged and thorough studies have established that not only does noise below 90 dB not prevent correct execution of activities /162 involving complex psychic processes (problem solving, memorization, learning, etc. [3]) but that even higher intensities (100-115 dB) do not always cause a decline of performance [4].

Among the characteristic factors of the activity its difficulty plays an essential role inasmuch as simple activities do not suffer because of noise [5, 6, 7]. Among the intermediate biological and psychological variables that come into play in diversifying the

effects of noise let us mention in the first place individual differences in auditory perception [8] and in the degree of neuropsychic activation [9] correlated with personality traits (introversion - extroversion) [10]. An important role is also played by the control the individual believes he is exerting over cessation of the noise [11], as well as his motivation, noise being judged to be less annoying in the case of strong motivation [12].

The conclusion of studies of the effects of noise on performance is that noise will exert a harmful action under the following circumstances:

-- a high intensity (above 95 dB), especially at high frequencies and in the event that it is discontinuous and aperiodic;

-- a difficult activity, which entails continuous attention;

-- overseeing, which entails shifting the attention among several sources of stimulation;

-- a negative attitude and insufficient motivation with regard to the noise and/or the activity in progress.

Finally, it must be emphasized that the noxious effects of noise are exerted especially on the correctness of the activity and less on the speed of its execution.

Though the studies carried out so far have not exhausted the /163
problems raised by the effects of noise, it is probable that the fundamental data established will not suffer any essential modification. On the other hand, there are areas in which further research is necessary, among which we might mention: the effects of prolonged habituation to noise, the execution of new activities involving noise by persons accustomed to working in noise, the effects of noise on the efficiency of a routine task that is usually performed in quietness, etc.

While the data obtained so far indicate the variability of the effects of noise on performance, the problems of its subjective effects are not disputed inasmuch as everybody complains about noise.

The final product of noise is psychic discomfort, whose level is influenced by many psychological, sociological, educational and other factors. In studies undertaken in the vicinity of airports Borsky [13] found that when he convinced local residents of the economic and political necessity of keeping the airport where it was, then the level at which they judged the noise to be disturbing dropped by 6 dB. Atherley et al. [14] likewise

find that the subjective importance accorded to noises will influence the attitude toward them and will lead to corresponding changes in physiological parameters while neutral noises produce no changes in comparison with the level of control. What is more, Hörmann et al. [15] have demonstrated that the discomfort, muscular tonus and temporary threshold shift (TTS) are dependent on the emotional attitude to noise (95 dB). Those for whom the noise constituted a confirmation of a better performance and therefore had a positive attitude were less annoyed and the TTS was lower /164
than in the case of subjects whose emotional attitude was negative (the noise was presented when they were making a mistake). We believe that another factor, too, comes into play in the production of discomfort, namely, aversion to noise. This depends on anxiety, it having been proved that anxious persons have a lower tolerance for noise than persons who are anxious but little [16], on familiarity with different noisy environments, on affective participation in the activity in progress [17], etc. It should be noted, on the other hand, that when the degree of aversion to noise was compared with that to electric shock, it was found that the latter is always judged to be more unpleasant.

Several studies have brought to light a great variability in the degree of psychic discomfort, which has led to the idea of the existence of an individual difference in susceptibility to noise and in the discomfort due to it. Thus, some persons who are sensitive to noise experience discomfort at moderate noise levels (50-60 dB) and other persons who are not very sensitive declare that they are scarcely annoyed by noise of 90 dB. It should be noted, however, that at this level, the discomfort curve rises sharply, so that in fact differences between groups appear at moderate noise intensities [18].

Investigating the action of different noises, including those generated by supersonic aircraft, Beker et al. [19] emphasize that persons sensitive to noise judge all noises, regardless of their intensity, to be more strongly annoying in their daily activity and regard the entire environment in which they live as being less acceptable than persons who are not very sensitive to noise. Persons who are sensitive to noise consider themselves more sensitive than the average and are convinced that noise affects their health. Differences in the degree of discomfort due /165
to noise and in sensitivity to noise do not depend on sex or age, nor on education or professional status. Different data indicate that in the case of work of the intellectual type discomfort is greater [20].

Though many of the data obtained from studies of this type are relevant, it is clear that many other investigations are necessary in order to delimit more precisely the concept of discomfort and the psychophysiological processes that underlie it and to

determine the "syndrome" of the psychophysiological reactions characteristic of discomfort due to noise.

At the same time, determination of a discomfort gradient and, concomitantly, of the influence of discomfort on performance would be useful and attended by practical consequences.

Implicitly or explicitly, there exists a noise "problem" such that noise in one way or another threatens man's well-being. The fact that prolonged exposure to noise generally leads to a loss of hearing has not only important medical, but also psychological, consequences that have inevitable repercussions not only on one's working capacity, but also on one's ability to participate fully in social life. Consequently, the finding of technological and economic solutions for reducing noise to acceptable levels is not an academic problem, but a problem of great practical and humanistic urgency.

Summary /167

Research conducted in the course of the last decade has disclosed that noise has harmful, favorable or no effects on human activity. This paradoxical situation is due to the great variability of the factors that define both noise and performance, as well as by very pronounced individual differences in reaction to noise. Many psychosocial surveys, as well as laboratory research, have concluded that regardless of the effect of noise on the level of performance, noise always causes psychic annoyance accompanied by physiological changes. The psychic discomfort varies with individual psychological factors as well as with the reactions of the social group.

Noise reduction is an essential condition for man's psychic comfort.

REFERENCES

1. Metz, B., J.-Ch. Mery, Rev. d'Acoust. 17, 345-347 (1971).
2. Kryter, K., The effects of noise on man, New York, Academic Press, 1970.
3. Broadbent, D.E., Decision and stress, London, Academic Press, 1971.
4. Harris, C.S., "Human performance effects of repeated exposure to impulsive acoustic stimulation," AMPL-TR-70-38, 1970.
5. Hockey, G.R.J., Q. J. Exp. Psychol. 22, 28-36 (1970).
6. Finkelman, J.M. and D.C. Glass, J. Appl. Psychol. 54, 214-220 (1970).
7. Gülian, E., Rev. psihol. 18, 323-333 (1972).
8. Stephens, S.D.G., J. Sound and Vibr. 20, 287-298 (1972).
9. Gulian, E., Zgomotul si activitatea umana [Noise and human activity], Bucharest, Edit. Academiei R.S.R., 1971.
10. Eysenck, H.J., The biological basis of personality, Springfield, Ill., Ch. Thomas, 1968.
11. Glass, D.C., B. Reim, and J.E. Singer, J. Exp. Soc. Psychol. 7, 244-257 (1971).
12. Munz, D.C., J.W. Ruffner, and J.F. Cross, Percept. Mot. Skills 32, 55-58 (1971).
13. Borsky, P., "Noise and the community," Chaba Report No. 4, 1954.
14. Atherley, G.R.C., S.L. Gibbons, and J.A. Powell, Ergonomics 13, 536-545 (1970).
15. Hörmann, H., G. Mainka, and H. Gummlich, Psychol. Forsch. 33, 289-309 (1970).
16. Sullivan, R., J. Abn. Psychol. 74, 646-650 (1969).
17. Kryter, K., Science 151, 1346-1355 (1966).
18. Moreira, N. and M.E. Bryan, J. Sound and Vibr. 21, 449-462 (1972).
19. Becker, R.W., F. Poza, and K. Kryter, "A study of the sensitivity to noise," AD-728.332, 1971.
20. Elias, R., R. Mateescu, and L. Zotovici, Rev. psihol. 18, 473-480 (1972).

Reproduced from best available copy.

EFFECT OF THE DURATION OF THE VIBRATION EXPOSURE ON THE LATE CHANGES IN THE ACTIVITY OF SOME OXYREDUCTIVE ENZYMES IN THE RAT KIDNEY **

E.IVANOVICH G.ANTOV M.ZLATEVA

CENTER OF HYGIENE-INSTITUTE OF HYGIENE AND INDUSTRIAL SAFETY-BULGARIA

The study of the enzymatic,morphological and functional changes in rat kidneys due to vibration effect has been the object of much researches.The data obtained so far don't give any information about the reversibility of the changes.

This report is an attempt to present in a short form some enzymatic changes of the rat kidneys after vibration exposure,as well as on the second and fifth month after,as revealed by biochemical and histochemical studies.Without neglecting the enzymic changes occurring immediately after vibration exposure,emphasis is placed on the latest changes,particulary on these obtained on the second and fifth month.The correlation of the enzymic changes with the prolongation of the vibration exposure is pointed out.

Material and Methods

A total of 96 male albino rats (60 experimental,36 control weight of 150 to 170 grams each in the beginning of the test,were divided into two groups.

I group - 30 animals treated with vibration two hours daily during a period of 10 days.

II group - 30 animals treated with vibration two hours daily, during a period of 30 days.

**The text of all articles written in English has been reproduced from the original book.

Reproduced from best available copy.

The experimental and control animals received a standard diet and water ad libitum.

The experimental rats were treated with total vertical sinusoidal vibration of the following parameters: 20Hz and 22 m/sec^2 acceleration, generated by the vibration set ST-3000-RFT

The animals of the first and second group were divided into groups of 10 animals, which killed by a decapitation on different terms after vibration exposure: a) 24 hours; b) 2 months; c) 5 months.

A fragment of the kidney was homogenised with physiological solution (1:10). Afters centrifugation, the activity of SDH, IDH and G-6-PDH in the supernatant were estimated as described by Kirschner. All enzymes activities were accounted to 100 mgr protein, which was estimated by Lowry.

Fresh frozen 15 μ thick sections from the kidney were used for the histochemical investigation. The method of Nachlas was used in order to demonstrate the activity of SDH and IDH. The method of Morri was used in order to determine the activity of G-6-PDH.

Results and Discussion

SDH - Immediately after the vibration exposure, the changes of the activity in the homogenates of the animals in both of the groups were not statistically authentic. This shows a tendency diminuation. Two months later the activity remained authentically depressed in both of groups. It is predominantly inhibited in the cells of the proximal tubules. Such a distribution pattern is seen on the fifth month after vibration treatment, but the activity is considerably inhibited only in the animals of the second group.

LDH - Twenty four hours after vibration treatment the enzymatic

170

activity is authentically decreased only in the animals from the first group.2 months after it is authentically depressed in both of the groups,but on he fifth month it is inhibited only in the animals from th second group.The changes of the enzymic activity are obviously much more expressed in the cells of proximal, than in the distal tubules.

G-6-PDH - 24 hours after vibration exposure the activity is not authentically decreased in the animals in both groups.On the second month it is significantly inhibited in the animals of both of the groups,but on the fifth month-only in the animals of the second group.The changes of the enzymic activity are obtained in cells of the proximal and in a smaller degree of the distal tubules.

The dats revealed from the biochemical and histochemical determinations show the following directions:

1).The activity of the investigated enzymes is decreased in the earlier terms after vibration exposure,as in the later one.

2).Whereas immediately after vibration treatment the activity of LDH is inhibited only in the animals of the first group.

3).Two months after the vibration influance,the activity of all investigated enzymes become authentically reduced,as in the 10-days treatment,so in the 30-days one.

4).On the fifth month after the end of the experiment however the activity of all estimated enzymes is inhibited only in the animals,killed after 30 days exposure to vibration.

By histochemical methods we observed differences in the distribution of the enzymic activity in some parts of the nephrone. Marked zonation is noted in all enzymatic staining reactions.

177.

Diminuation in the number of stainable granules is noted not only in the following two months after vibration treatment, but also after 5 months. The most significant changes of the determined dehydrogeneses activity are obtained in the cells of the proximal and distal tubules.

The data about the changed activity of the examined enzymes, involved in the glucolysis and synthetic processes and metabolic transport functions, may be due to distribution of the total metabolism in thetubular cells.

It must be pointed out, that the earliest enzymic changes namely the changes of LDH are related with the glucolyse, thus indicating a depression of oxidative respiration. These changes are presented predominantly in the cells of proximal tubules, which are involved in the glucolitic processes. The inhibited activity of LDH results a suppression of the energy spare of the cells, which is supported by the data of the data of the inhibited activity of G-6-PDH. Another point that must kept in mind is the signifficant diminuation of the activity of this enzyme, which is obtained in the later terms after the vibration exposure and remains till the fifth month. The results of histochemical staining reactions, showing localization changes of the enzymic activity in the field of the proximal and distal tubules may be correlated with hypoxaemic distribution in the tissue of the kidney. As well as it is known, the proximal and in some rats the distal tubules cells are involved in the reabsorbation and secretion processes. This marked late[illegible] ges of the dehydrogenesis activity would show a beginning of the metabolic disturbances in the further terms after the vibration exposure.

72

The data about the enzymatic activity of the kidney and liver on the second and the fifth months after the vibration treatment indicate a smaller adaptation and regeneration possibility of the kidney's tissue.

In conclusion it is possible to state:

1).The changes of the oxydative enzymes activity in the rat kidney's tissue occurring after vibration exposure are much more expressed on the latest terms.

2).These late changes are in a direct dependance on the duration of the vibration treatment.

Summary

This report is an attempt to present in a short form some enzymatic (SDH, LDH and Gl-6-PDH) changes in the rat kidney after vibration (20Hz, 22,0 m/s^2) exposure (10 days and 30 days), as well as on the second and fifth months after, as revealed by biochemical and histochemical studies.Without neglecting the enzymatic change occuring immediately asfter vibration exposure amphasis is placed on the second and fifth months.The correlation of the enzymic chnages with the prolengation of the vibration exposure is pointed out.

EVALUATION OF OCCUPATIONAL NOISE AND ITS SPECIFIC EFFECTS IN VARIOUS INDUSTRIES

D. Mocanu, G. Mihail, and V. Popovici
Institute of Public Health and Medical Research,
Iasa, Romania

The influence of noise on the human organism in general and /175
on hearing in particular has been known for some time; at the present time, however, owing to the penetration of technology into all areas of activity, noise sources have increased in number and intensity, so that the problem of the influence, prophylaxis and combating of noise has acquired exceptional importance.

Statistical studies by German authors have shown that the real situation with regard to occupational hypoacusias in Europe is not exactly known because of the weak tracking and incorrect reporting of this morbidity. According to Allan Bell [2], the absence of uniform legislation in all states and of unified criteria for evaluating the noxa and its effects, as well as the latency of protective measures, demonstrate the necessity of developing research programs in this domain at the international level.

In the present study we investigated the effects of occupational noise on the auditory apparatus of workers in different industrial sectors and even in sectors considered to be quieter, for the purpose of evaluating the incidence and intensity of hearing threshold drops as a function of the physical characteristic of the noise sources, the length of exposure and the coexistence of other stress factors on the job.

Methods and Materials

Our research was conducted in the metallurgical industry (sections: blast furnace, rolling mill, steel foundry, turboblowers, lime plant), the chemical industry (sections: conversion, graining, polycondensation), the textile industry, the timber industry and agriculture.

The principal characteristics of the groups of workers investi- /176
gated were as follows: young average age and long exposure of women workers in the textile industry exposed to noise of constant intensity, the presence of some concomitant stress factors (physical and chemical noxae) in the metallurgical industry and the absence of other noxae, as well as the action of an open-air noise source for workers in the timber industry and agriculture.

The sonometric determinations were conducted with a Tesla ZKM_2 apparatus, and the audiometric examination was conducted with a portable Elsa Aug 64 audiometer. In the absence of ideal conditions of phonic insulation, the audiometric examination was conducted in a quiet room, taking into account only those drops in hearing that exceeded 30 dB for the 125-10,000 Hz frequency range for osseous conduction and air conduction. The anamnesis and clinical examination completed the audiometric examination.

A. Results of Acoustic Measurements

1. Metallurgical Industry

a) Air blower section. The noise sources of the air blower section are turbines, turboblowers and boilers. Noticeable is the uniform and continuous character of the noise, with a predominance of middle frequencies. Total noise varies from 98 to 108 dB in the different work spaces investigated. The Cz_{85} curves were exceeded in the turbine room and in the neighborhood of the turbogenerator in the 500-8000 Hz frequency range.

b) Rolling mill section. Noise is generated by the slab transportation system and impacts against rollers and platforms, which gives an intermittent character to the noise against the constant background noise generated by the rollers. Total noise varies from 88 to 102 dB. The Cz_{85} curves are maximally exceeded (25 dB) incident to the passage of the sheet metal on the rollers in the 4000 Hz frequency zone outside the cabin and by 15 dB inside the cabin. In these work spaces 5-15 dB excesses were recorded in the 250-8000 Hz frequency range.

c) Blast furnace section. Noise in the blast furnace section is generated by the operation of the furnace (loading, unloading, oxygen blast) and has a continuous and constant character. Total noise varies from 82 to 108 dB with the Cz_{85} curves being maximally exceeded by 15-20 dB at 4000 Hz during unloading of the cast iron.

d) Steel mill section. Noise is generated by the operation of the converters. Total noise varies from 89 to 96 dB. No deviation from the Cz_{85} curve can be observed. /177

e) Lime plant. Noise exceeds the Cz_{85} curve throughout the 63-8000 Hz frequency range, with a maximal intensity of 110 dB at 1000-2000 and 4000 Hz.

2. Chemical Industry

a) Graining section. The Cz_{85} curves are maximally exceeded at 1000 Hz in the neighborhood of the graining machines (102 dB).

b) Compressor section. The Cz_{85} norms in the 1000-4000 Hz frequency range are more moderately exceeded.

3. Textile Industry

In the loom hall the total noise from different points of the room has a constant and continuous character with an intensity of 102-103 dB. Spectral analysis shows that the Cz_{85} curve is exceeded by 5-12 dB in the 500-1000 Hz frequency range.

4. Timber Industry

The total noise generated by mechanical saws of the "D" type ranges from 87 dB to 104-106 dB, reaching 108 dB at full speed. The Cz_{85} curve is exceeded by 10-12 dB in the 500-4000 Hz frequency range. For saws of the "R" type the noise attains an intensity of 116-117 dB.

5. Agricultural Sector

The total noise generated by the tractor in the worker's hearing range varies from 80 to 90 dB. The Cz_{85} curve is more noticeably exceeded (10-12 dB) in the 500-1000 and 2000 Hz frequency range. There exist variations connected with the load of the motor, the number of revolutions, the speed, the presence or absence of a cabin, etc.

B. Results of the Audiometric Examination

1. Metallurgical Industry

Of the 328 workers examined with an average age of 30 years and a length of service of 10 years, 59.9% turned out to have different degrees of hearing loss, of which 48.1% were hypoacusias of an occupational nature and 11.8% were due to other causes. Most of the occupational hypoacusias occurred at 4000 Hz; 22.5% were incipent, 25.6% were intermediate and 39% had good hearing. /178
In general, the percentage of hypoacusia cases increases with length of exposure. In view of the different conditions as regards intensity and the noise spectrum in different sections, the percentages differ from section to section (Fig. 1).

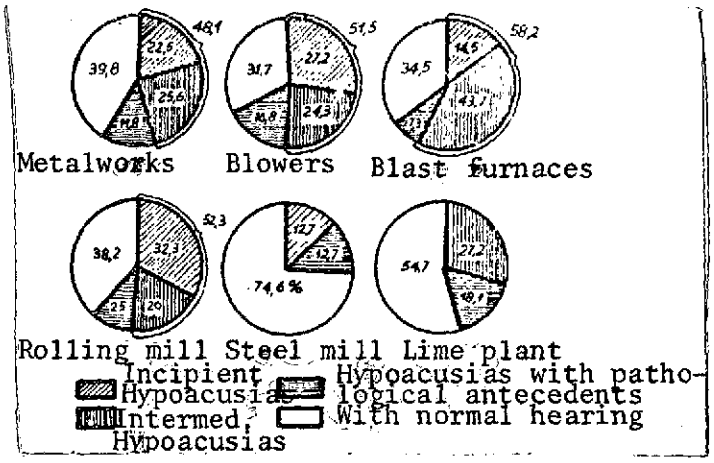


Fig. 1. Incidence of hypoacusia; total for the metalworks and for different sections.

a) Blower section. Of 107 workers examined, 31.7% had normal hearing, 16.8% had hypoacusias due to pathological antecedents and 51.5% had occupational hypoacusias (27.2% were incipient and 24.3% were intermediate).

b) Rolling mill section. Of 115 workers examined, 38.2% had normal hearing, 52.3% had drops in the hearing threshold due to occupational noise (of which 32.3% were slight drops and 20% were intermediate) and 9.5% had hypoacusias due to extraoccupational causes.

c) Blast furnace section. Of 55 workers examined, 34.5% had normal hearing, 58.2% had different degrees of drops in the threshold (14.5% were slight and 43.7% were intermediate) and 7.3% had hypoacusias with pathological antecedents. Noteworthy is the increased proportion of hypoacusias in this section, which can be attributed to the intensification of the effects of noise due to the presence of associated stress factors, one of the most /179
important of which is the ototoxic action of CO described by other authors (Lumio, Sirala, Tanievski, Kugler, et al.).

d) Steel mill section. Of 29 workers, 22 had normal hearing (74.6%), 12.7% with slight incipient hypoacusias and 12.7% with pathological antecedents.

e) Lime plant. Fifty-four percent had normal hearing, 27.2% had intermediate hypoacusias and 18.1% had pathological antecedents.

2. Chemical Industry

Of 163 persons examined (87% of whom were women with an average age of 22.9 years and an average length of noise exposure of 1.7 years), 68% had normal hearing, 15% showed drops in the hearing threshold in an incipient form, probably reversible after auditory rest, and 17% had hypoacusias with pathological antecedents.

3. Textile Industry

Of 256 workers examined with an average age of 33.1 years and average length of noise exposure of 13.4 years, of whom 110

persons had approximately 20 years of service, 62% had occupational acusias, of which 6.2% were incipient, 51.1% were intermediate and 4.6% were acute. 22.8% had normal hearing and 15.2% had pathological antecedents.

4. Timber Industry

Of the 85 workers with mechanical saws whom we examined, with an average age of 37 years and an average occupational exposure of 5.8 years, 40.6% had characteristic hypoacusias, of which 13.9% were slight, 18.6% were intermediate, and 8.1% were advanced, with significant hearing losses in the frequency range above 6000 Hz.

5. Agricultural Sector

Of the 112 tractor drivers with an age of 20-40 years and a length of service of 2-15 years, we found occupational changes in the acuity of hearing in 28.2%, of which 14 cases were incipient, seven were intermediate and nine were advanced, 15.2% with hypoacusias due to pathological antecedents and 56.6% with normal hearing (Fig. 2).

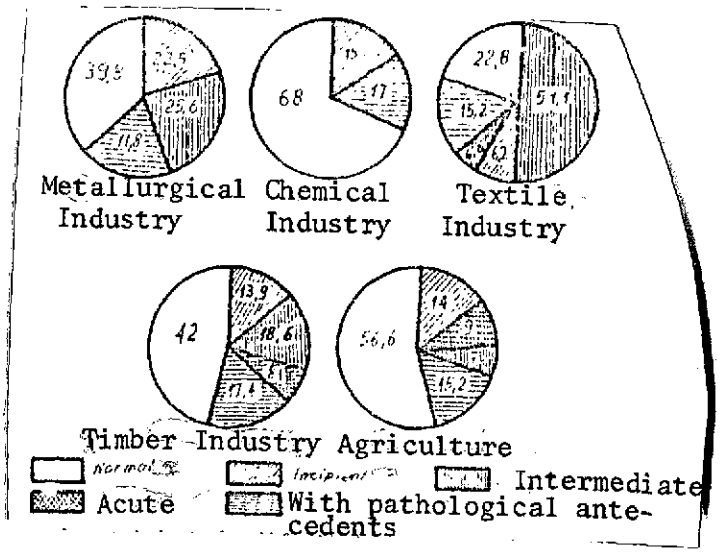


Fig. 2. Incidence of hypoacusias in different industrial sectors with different exposures to occupational noise.

Conclusions /180

In the different industrial sectors and work spaces investigated, there exist sources of noxious noise that can cause occupational hypoacusias.

-- as a rule, whenever the Cz curves were exceeded, hypoacusias appeared.

-- there exists a directly proportional relation between intensity of noise and its noxiousness and between length of noise exposure and gravity of hearing losses.

-- individual differences in sensitivity or increased resistance to noise play an important role in the appearance and evolution of occupational hypoacusias.

-- the increased effects of noise in the presence of associated noxious factors point to their intensifying action.

-- prehiring and periodic clinical ORL and audiometric examination must become obligatory for workers exposed to noxious noise, and so must the declaration of occupational hypoacusias as an occupational disease. The attitude and measures to be adopted for hearing losses must be evaluated on an individual basis.

Summary /183

In order to evaluate the influence of noise on exposed workers in different industrial sectors, we first carried out acoustic determinations of the noise level in work spaces that exceeded the Cz_{85} curves. The results of tonal audiometry showed drops in the hearing threshold in different proportions in the investigated sections (agriculture, timber industry, metallurgical industry, chemical industry, textile industry) as a function of intensity, duration and stage of exposure, as well as of the special characteristics of the noise. The authors discuss the possible influence of associated factors in the work environment as regards the increased effects of noise in some industrial sectors.

REFERENCES

1. Baughn, W.L., "Noise control. Percentages of protected population," Engl. J. Med. 275/14, 759 (1966).

2. Bell, Allan, "Noise," Cahiers de Santé Publique 30 (1967).

3. Cervellera, G. and A. Carducci, "Investigations of occupational deafness: The pure form of lesions of the labyrinth in acoustic trauma," Arch. Ital. Otol. 75/2, 161 (1964).

4. Cis, C., A. Ottaviani, et al., "General local causal factors in industrial acoustic trauma," Arch. Ital. Otol. 75/6, 709 (1964).

5. Fabiani, G., "On early diagnosis and prophylaxis of occupational hypoacusias," Zeitschr. der. Ges. Hyg. 7, 508 (1968).

6. Fabiani, G., "Comparisons between tonal and vocal audiograms in persons with hypoacusias due to noise," Zeitschr. der. Ges. Hyg. 3, 165 (1968).

7. Fournier, J.E., Roinville, "Audiometric study in a metallurgical enterprise," Arch. Mal. Prof. 28/6, 523 (1967).

8. Glorig, A., "Permanent changes in the excitability threshold caused by noise and vibrations," Amer. Ind. Hyg. Assoc. J. 25/3, 237 (1964).

9. Gradina, C., C. Anitescu, et al., "Some physiological reactions observed in persons experimentally exposed to 500 and 1000 Hz tones," Fiziol. Norm. si Pat. XIV/5, 453 (1968).

10. Hipskind, M.M., "Hearing tests in industry," Ind. Med. Surg. 36/6, 393 (1967).

11. Kishi, K. et al., "Studies of individual exposure to noise," Exo. Medica 10/3, I, 170 (1965).

12. Kovaleva, L., "Effects of industrial noise on the auditory apparatus of adolescents," Gig. i sanit. 1 (1967).

13. Lawrence, M., "Modern conceptions of the mechanism of occupational hypoacusias," Amer. Ind. Assoc. J. 25/3, 269-273 (1964).

14. Lüpke, A.V., "Present-day problems in the determination of noises and their diminution on the job," Prot. Muncii 1/2, 66 (1967).

15. Mary, J., "The character, effect and evaluation of intermittent noise in industry and residences," Arch. Mal. Prof. 6, 381 (1968).

16. Schurno, A.S. and D. Dahl, "On hypoacusias of riveters of the construction industry," Zeitschr. der ges. Hyg. 3, 161 (1968). /182

17. Valtat, M., "Audiometry," Revue du Praticien II, 13bis, 2229 (1970).

18. Zenk, [illeg.], "Occupational hypoacusias in the German Democratic Republic between 1956-1960," Zeitschr. der ges. Hyg. 9/11, 841-850 (1963).

IMMUNOELECTROPHORETIC CHANGES IN SERUM PROTEINS IN RESPONSE TO HIGH-FREQUENCY VIBRATIONS

S. Zwetkov and B. Petrounov
Academy of Medicine, Health Center, Bulgarian People's Republic

Recently there has been increasing interest in research on /185
the effects of vibrational energy on the organism, in connection with the use of vibration-producing techniques in certain industrial fields and the appreciable increase in the number of workers subjected to vibration.

Detailed studies have been performed not only on functional and morphological changes in the most clinically affected systems and organs (the nervous system, the cardiovascular system, the osteoarticular system, the auditory organ), but also on changes in other systems and organs (the liver, the kidneys, the suprarenal glands, the gastrointestinal system, the gonads), changes in the processes of protein, carbohydrate, lipid, electrolyte and vitamin metabolism, enzymatic changes, changes in immune reactivity, etc.

There have been numerous studies on the effects of vibration on certain mechanisms of protein metabolism: Bondarev, G.I., et al. [2], Michelson, D.A. [11, 12, 13, 14], Petrova, A., et al. [17], Freytag, J., et al. [4], Getzen, L. [5], Gregozyk, I. [7], Petelenz, T., et al. [16], Koziolova, H., et al. [9], and many others (we are aware of more than 40 studies in this area).

Changes in the immune properties of proteins under the effects /186
of vibration in experiments and in vitro have been described by Alexeeva, O.G., et al. [1], Okolov, F.S., et al. [15], Flume, I.L. [3], and Martin, W., etaal. [10]. Immunoelectrophoretic changes

in serum proteins in response to vibrations of nearly ultrasonic frequency (16 kHz, in vitro) have been discussed by Grzezik et al. [8].

All of the studies cited (with the exception of those dealing with the effects of vibrations in vitro, in which the vibrations are used solely as a method), have been performed using low- and average-frequency vibrations (up to 100 Hz). The constant increase in fundamental frequency and the amplitudes of the high-frequency harmonics of many vibrating industrial devices (hammering machines, electric and pneumatic polishers and grinding machines, electric and gasoline-operated slaughtering machines, etc., whose fundamental frequency may even be as high as 500-1000 Hz), as well as studies on the effects of high-frequency vibration on various functions of the nervous, cardiovascular and osteoarticular systems (showing significant differences in nature and degree, with similar alterations, in response to low- and average-frequency vibrations), prompted us to study certain changes in protein metabolism and in the enzymatic activity of the organism in response to high-frequency vibrations.

The object of this experimental study was to reveal changes in the immunoelectrophoretic profile of serum proteins under the effects of high-frequency vibrations.

Methods and Equipment /187

The effects of general vertical vibrations with a frequency of 150 Hz and amplitudes of 0.05 mm and 0.5 mm were studied with regard to male white rats, aged two to three months, with initial weights of 150-200 g. An RDA ST-3000 vibrating Stend was used. The animals were agitated one hour a day for 45 days. Since the Stend produced audible noise (76 or 96 dB, depending on the amplitude), control animals were placed in the vicinity of the unit (in the same compartment) during the experiment to provide a

means of comparison by which the influence of sound could be eliminated. The animals were examined prior to the experiment and 10, 15, 30 and 45 days after it had begun. Protein immunoelectrophoresis was performed on the blood serum using the P. Crabar method [6].

Antirat immune serum was obtained by immunizing rabbits with a rat serum (antigen) prepared in a medium of Freund's adjuvant.

During the experiment, serums from the experimental and control animals were simultaneously placed on each plate and tested to obtain direct comparison under the same conditions.

The differences between the experimental and the control animals were determined visually by the absence or very slight presence of different precipitation curves.

Results

The precipitation curves obtained corresponded to α_1, α_2, β_1, β_2, and γ globulins. During the preliminary experimentation no appreciable individual differences were noted between the two experimental series (amplitudes 0.05 and 0.5 mm). Similarly, during the experiment the control animals showed no appreciable individual deviations in response to high or low frequency, nor were the precipitation curves absent. /188

The following results were obtained using vibrations with an amplitude of 0.05 mm:

On the 10th day there were no notable differences between the experimental and the control animals.

Of the eight tests made on the 15th day (eight experimental and eight control [sic]), the β_1 globulin precipitation curves

were noted to be flat for serum from three of the experimental animals.

On the 30th day, in nine tests of five serums from experimental animals, the β_1 precipitation curves were relatively flat or nonexistent.

On the 45th day, in all nine tests of five serums from experimental animals, the β_1 precipitation curves again were either relatively flat or nonexistent.

Analogous changes were noted inrresponse to vibrations with an amplitude of 0.5 mm:

On the 10th day, all ten tests of serums from two experimental animals revealed an absence of β_1 precipitation curves.

On the 15th day, ten tests on a single serum showed no β_1 precipitation curve.

On the 30th day, eight tests on two serums from experimental animals showed no β_1 precipitation curves.

On the 45th day, again, eight tests on two serums showed no β_1 precipitation curves.

From these results it can be seen that constant changes occur in the antigenic chracteristics of serum protein in response to high-frequency vibrations, these changes being expressed as an absence of the precipitation curve, or in some cases a relatively flat curve. /189

However, no correlation was observed between the amplitudes tested (0.05 mm and 0.5 mm) and the degree, number and nature of

the changes noted. A greater number of changes was actually observed at the smaller amplitude, but the changes generally appeared earlier at the higher amplitude -- on the 10th day.

Discussion

The changes in total serum protein content and in the fractions of different blood serum proteins may be caused by various factors: lesions of the liver, the basic producer of serum proteins, linked to changes in the rate of protein synthesis, qualificative changes in synthesis, an increase or decrease in the permeability of the lipoprotein membranes, the size differences of various protein molecules, etc.

The occurrence of precipitation curves during the immunoelectrophoretic process depends not only on the quantity of protein fractions but also on their antigenic characteristics.

The antigenic characteristics of protein are considered to depend primarily on the active groups present: sulfhydrous, amino, imino, hydroxile. Extremely characteristic changes in the immunoelectrophoretic profiles of serum proteins in a large part of the experimental animals -- a decrease in or disappearance of the β_1 precipitation curve -- are probably linked to a parenchymatous lesion of the liver in response to both the direct and the indirect effects (the latter through neurohormonal regulation) of high-frequency vibrations. These alterations would be of a permanent nature (10-45 days) leading toward changes in the amount of groups active in protein synthesis and resultant changes in the antigenic characteristics of these groups. This theory may also be demonstrated by the lack of constant change in the quantity of serum β_1 globulin, the relative percentage of hepatic protein fractions (data presented in our other studies) and the identical immunodiffusion conditions. In our opinion, the decrease in total serum protein, linked to the decrease in the rate of protein synthesis

/190

(decrease in the quantity of amino acids in the liver indicated by C^{14}) expressed as an absolute decrease in all protein fractions and the decrease in sulfhydrous groups in the serum and hepatic proteins (data presented in our other studies), also reveal changes in the antigenic properties of the proteins.

Conclusion

1. High-frequency vibrations (frequency 150 Hz and amplitude 0.05 mm and 0.5 mm) produce changes in the immunoelectrophoretic profiles of serum proteins in white rats.

2. The changes were extremely characteristic and were linked with a decrease in or the absence of the β_1 precipitation curve.

3. These changes appeared very early -- 10-15 days after the beginning of the experiment -- and were permanent (although they were not observed in all the experimental animals).

4. The changes were most probably due to a hepatic lesion resulting from both the direct and the indirect effects of the vibrations (the latter through the agency of neurohormonal regulation), leading to changes in the quantity of free active groups during protein synthesis and resultant changes in the antigenic properties of the proteins.

Summary /192

The effect of high frequency vibrations on the immunoelectrophoretic profile of blood serum proteins has been examined. Tests were performed on white rats subjected to vertical and sinusoidal vibrations with a frequency of 150 Hz and amplitudes of 0.05 mm and 0.5 mm, one hour a day for 45 days.

Changes in the immunoelectrophoretic profile of proteins were

examined on the 10th, 15th, 30th and 45th days. In a certain number of cases the β_1 precipitation curve was flattened or completely absent; this phenomenon occurred relatively early in the experiment and was permanent (up to the 45th day).

The study shows that these changes were due to a hepatic lesion resulting from the direct effects of the vibrations, as well as their indirect effects, through the agency of neurohormonal regulation.

REFERENCES /191

1. Alekseewa, O.G., et al., Probl. kosm. biologii 1, 81 (Moscow, 1962).
2. Bondarev, G.I., et al., Gig. truda 10, 58 (1968).
3. Flume, J.Z., USAF Sch. Aerospace Med. 4, 48,(1962).
4. Freytag, J., et al., Med. Pracy 4, 369 (1961).
5. Getzen, Z., Surg. Gynec. Obstet. 119, 125 (1964).
6. Grabar, P., ed. by O. Glich, New York, 11, 1, 1959.
7. Gregorczyk, J., et al., Acta Physiol. Pol. 17, 1, 107 (1966).
8. Grzezik, J., et al., Acta phys. pol. 18, 5-6, 679 (1966).
9. Koziołowa, H., et al., Polski hygodnuk lekarski 18, 43, 1597 (Warsaw 1963).
10. Martin, W., et al., Lab. Pract. 19, 7, 703 (1970).
11. Michelson, D.A., Wopr. Pitan. 28, 6, 54 (1969).
12. Michelson, D.A., Materiali konf. molod. spez. po probl. pitania zdarowowo i bolnowo tcheloweka [Proceedings of the Conference of Young Specialists on Nutritional Problems in Healthy and
13. Sick Persons] 79 (Moscow 1968).
13. Michelson, D.A., et al., Materiali 3-wo mejdunar. simposiuma po morskoi medizine [Proceedings of the 3rd Symposium on Naval Medicine], p. 24 (Leningrad 1968).
14. Michelson, D.A., Gig. i. san. 34, 9, 129 (1969).
15. Okolov, F.S., etaal., Jurn. mikrobiologii 40, 1, 10, 47 (1963).
16. Petelenz, T., et al., Med. Pracy 17, 4, 296,(1966).
17. Petrowa, G.P., Kosmitcheskie issledowania 2, 335, 340 (1964).

INVESTIGATIONS OF EXPOSURE TO VIBRATIONS IN COAL MINES

Hilda Horman and G. Dirlea
Institute of Scientific Research for Labor Protection
Research Station for Mining Safety, Petrosani, Romania

In the mining industry large-scale use is made of hand-operated pneumatic percussive implements such as drill hammers and pick hammers, whose operation generates vibrations that are directly transmitted to the worker's organism. Inasmuch as vibration sickness is well known to persons who work with implements of this type, in the present study we conducted some investigations of the characteristics of exposure to vibrations in coal mines, with a view to the adoption of the necessary preventive measures against their noxious action. In general, the literature contains but scanty data about the problem of vibration sickness in the mining industry. /195

Methods

We conducted vibration measurements and some physiological investigations of the workers' organism.

The vibrations caused by the CP 19 drill hammer and the CA 15 pneumatic pick hammer were measured with a portable Brüel and Kjaer phonometer equipped with an accelerometer, for frequencies of 31.5, 63, 125, 250, 500, 1000 and 2000 Hz. The transducer was applied to the handle of the implements and to a number of points on the surface of the human body in order to determine the transmission and degree of damping of the vibrations at different levels of the organism: the dorsal side of the hand and of the articulation of the fist (metacarpal and carpal regions), the elbow (on the head of the cubitus), the scapulohumeral articulation (on the achromion) and the first few cervical vertebrae [7]. At the same time, the worker's positions during work were investigated.

The physiological investigations, which were conducted during the cold and the hot periods of the year, were aimed at the effect of vibrations on the hand in a group of miners, who were 30-40 years old and had been working with the pick hammer for 8-12 years, and in a control group consisting of workers who did maintenance work in the pit (fitters, electricians), who were of the same age and had the same length of service in the pit as the investigated miners. The sensitivity to vibrations and vascular reactions of the hand that holds the tool handle were determined before and after work by measuring skin temperature and heating reaction. Because of the specific conditions in the pit, the investigations were conducted at the earth's surface, near the mine exit.

Sensitivity to vibrations was determined in 53 miners and 22 controls, on the palmar surface of the middle finger and the phalanx of the index, at frequencies between 20 and 1000 Hz, obtained with a vibration exciter fed by a Brüel and Kjaer frequency oscillator, the measurements being conducted under acceleration.

Skin temperature was measured with a thermocouple on the dorsal surface of the middle finger and the phalanx of the index in 100 miners and 30 controls. The heating reaction was determined according to the method described by K. Buggar-Meszaros and applied by G. Cadariu et al. in research on the influence of vibrations from pneumatic pick hammers on the organism [3]; normally, the heating reaction lasts 45-75 seconds. /196

Microclimatic factors also were measured on the outside. The microclimate in the pit was not determined inasmuch as this problem was studied in Romania by some of us [6] over a period of a few years, a great part of this research being conducted in the same mine in which the present study was carried out; these data were incorporated into this study.

Results

Vibration characteristics. The values obtained for the vibrations transmitted to the organism by the pick hammer are shown in Tables 1 and 2, from which it can be seen that their acceleration and shift in almost every case exceeds the values of the permissible limit curves.

Drill hammer and pick hammer are generally supported by both hands: one hand, usually the right, is applied to the handle, supporting the weight of the tool, while the other hand is applied to the drill of the drill hammer or the pick or body of the pick hammer, directing it during work. Inasmuch as the tool is heavy, the worker must put out a considerable effort to keep it in the most advantageous position, which causes an intense and continuous forced contraction of the entire musculature of the upper limb and of the scapulohumeral region, an effort that becomes more intense when the tool is operating in a horizontal or upward direction into the ceiling of the drift or working, so that the miner can support its weight against the force of gravity (Fig. 1). At the same time, other large groups of muscles are involved (muscles of the thorax and of the lower limbs) in order to maintain the position of the body necessary for work and sometimes also to exert pressure on the tool or to assure it a supporting surface. This contraction fosters the transmission of vibrations to the organism, or to the bones and, especially, to the articulated areas (Andreeva-Galanina, L. Dérobert) [3, 5], a fact confirmed by t

by the vibration values we measured at a number of points on the body's surface, which are still high enough in spite of all the damping that takes place in different regions.

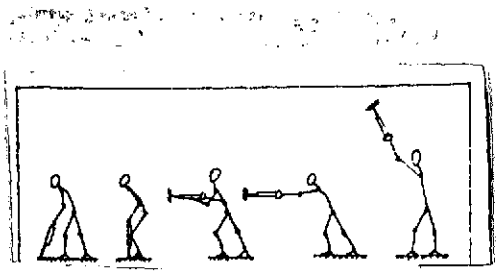


Fig. 1. Some characteristic positions of the miner while working with the drill hammer.

The greatest accelerations were found on the dorsal surface of the hand and of the articulation of the fist and at the elbow, especially for frequencies of 31.5 and 63 Hz. On the dorsal surface of the hand and the fist, acceleration was greater in the case of the hand applied to the drill, with an increase at the articulation of the fist and a great decrease at the elbow, where it follows that considerable damping occurs. In the case of the hand grasping the handle, after damping of the vibrations at the articulation of the fist, their acceleration increases very much at the elbow. We believe that these changes are due to the different positions of the upper limbs as well as to the muscular contraction for different stresses that fosters damping or transmission of vibrations.

As far as shifting is concerned, we found that the permissible limits are exceeded in the dorsal region of the hand. The highest values were found at frequencies of 31.5-125 Hz (Table 2).

Microclimate. The effect of the vibrations generated by drill and pick hammers is fostered by the cold present in the pit, which plays a role in the production of vascular spasm. This cold is brought about in the first place by the jet of compressed air, which has considerable cooling power because of its great speed and low temperature due to abrupt expansion. There also exist in the pit a great number of places with lower air temperatures, often associated with great air-current speeds (drifts, frontal workings, galleries) (Table 3) [6]. Another source of cold is the high humidity of the air in the mine's work spaces (88-98%) (Table 3), which is sometimes due to the presence of water in many mine workings or to the use of wet drilling, which leads to contact of the hands with the cold water used in this drilling. /197
In the Krivoi Rog basin, the presence of water under wet drilling conditions fostered a rapid development of vibration sickness, reducing the time for its advent from 6-10 years to 7 ± 1.5 years [7]. Some authors have observed that exposure to cold entails a smaller risk if it is limited to the hands and a greater risk if it reaches the miner's entire body [2, 9], as is the case in mines, especially in galleries.

TABLE 1. ACCELERATION OF VIBRATIONS TRANSMITTED TO ORGANISM BY CP 19 DRILL HAMMER (cm/s^2).

	Drift									Working								
	Hand on Handle					Hand on Drill				Hand on Handle					Hand on Drill			
Hz / Place	Hand	Fist	Elbow	Shoulder	Cervical Vertebrae	Hand	Fist	Elbow	Shoulder	Hand	Fist	Elbow	Shoulder	Cervical Vertebrae	Hand	Fist	Elbow	Shoulder
31,5	600	310	850	310	210	350	1200	180	110	600	310	360	310	210	350	1300	180	80
63	310	95	470	32	46	210	310	46	26	300	95	470	51	24	180	480	46	30
125	240	60	95	18	4,2	110	60	8,4	18	240	60	95	18	4,7	118	60	15	18
250	150	45	18	3,5	0,95	150	15	4,7	5,4	150	18	18	5,8	0,65	65	15	4,3	3,5
500	60	6,6	2,6	1,1	0,19	32	6	2,0	2,1	60	9,5	3,0	0,95	0,19	12	6	3,0	1,8
1000	18	2,1	1,5	0,46	0,13	12	4,3	0,75	0,21	18	2,4	1,7	0,42	0,085	6	4,8	0,75	0,21
2000	13	0,85	1,3	0,31	0,13	2,1	0,66	0,40	0,26	15	0,95	1,5	0,26	0,15	4,2	0,60	0,40	0,30
Total	1200	460	950	290	190	840	1060	300	180	1200	410	840	290	180	950	1300	300	150
mm	0,95	0,95	0,22	0,08	0,045	0,28	0,4	0,08	0,1	0,95	0,95	0,45	0,07	0,045	0,28	0,35	0,07	0,11

Reproduced from best available copy.

#Total shift

TABLE 2. SHIFTS OF VIBRATIONS TRANSMITTED TO THE ORGANISM BY THE DRILL HAMMER (mm).

	Handle				Drill		
Hz / Place	Fist	Elbow	Shoulder	Cervical Vertebrae	Fist	Elbow	Shoulder
31,5	0,022	0,018	0,009	0,0028	0,022	0,01	0,18
63	0,0056	0,0035	0,0021	0,0013	0,0022	0,003	0,022
125	0,0021	sub 0,0007	0,001	sub 0,0003	sub 0,0003	0,0003	0,009
250	0,0009	"	0,0009	"	"	sub 0,1003	0,0008
500	sub 0,0007	"	sub 0,0003	"	"	"	sub 0,0001
1000	"	"	"	"	"	"	"
2000	"	"	"	"	"	"	"
Total	0,45	0,25	0,07	0,045	0,35	0,07	0,4

Key: sub = below

Skin temperature. Tables 4 and 5 show the results of our skin temperature measurements. Differences can be observed in the values obtained for miners and controls, skin temperature in the case of the former being lower than in the case of the latter, before as well as after work; differences due to the outside temperature also existed.

Noteworthy is the fact that at the end of work the skin temperature of miners did not show higher values as compared with the start of work, and this was so especially in the case of lower outside temperatures. Investigations conducted by G. Cadariu et al. [3] on workers cleaning castings with a pneumatic pick hammer showed at the end of work an increase in skin temperature by 3-8°C; these examinations were conducted immediately after work in a room located in the production hall. In the case of our study, on the other hand, the workers passed from their work space to the place of examination through the mine galleries, /198 under conditions of high air-current speeds (Table 3), a factor which fostered peripheral vasoconstriction and, consequently, lower skin temperatures. This cause was confirmed by the fact that at an outside temperature of 15.9°C, skin temperature was higher than at 8.5°C (Table 4) inasmuch as in the latter case the air-current speed was greater in the principal gallery, the difference between outside temperature and that inside the mine being greater. The distribution of the skin temperature values can also be explained in this manner in the sense that in the month of July no values below 24°C were found at the mine exit, whereas in the month of November skin temperature was below 24°C in 19.9% of the miners investigated (Table 5). At the same time, as we have shown, in the case of the pit another factor comes into play, namely, humidity, which was not present in the case of the cleaning of the castings.

Our results show that pit workers who worked an average of 10 years with the drill hammer and pneumatic pick hammers show disorders of the peripheral vessels that appear as spasms, which are the more intense and last the longer, the lower the temperature of the environment. In this case, exposure of the hands to cold triggers a vasoconstriction that lasts after the exposure to cold has ceased, which explains why the skin temperature of some subjects, after sitting for 10-20 minutes in the examination room at a temperature of 24-26°C, did not increase but even decreased by 1-2°C.

Heating reaction. It can be seen from Table 6 that in the majority of subjects investigated, the heating reaction was within normal limits before as well as after work. The number of miners with a heating reaction beyond 75 seconds was greater than the number of controls; thus, before work 16% of the miners showed a heating reaction beyond 75 seconds while the control group showed not a single case of delayed heating reaction. After work, the

TABLE 3. MICROCLIMATIC FACTORS IN DIFFERENT ZONES OF THE PIT.

Microclimatic Factors	Season	Measurement Site									
		Outside	Mine Exit	Principal Gallery		Transversal Gallery		Access Gallery	Drift	Working	
				500 m	1000 m	1500 m	2000 m			Chamber	Front
Temperature, °C	Sum	21.2	21.2	16.9	13.9	15.2	17.0	13-24	10-22	30.0	13-25
	Win	2.6	2.6	3.6	5.2	9.7	15.4	11-24	---	30.0	---
Relative Humidity, %	Sum	66	66	78	84	93	90	90-96	88-96	96	89-95
	Win	67	67	80	81	72	85	88-96	---	89	---
Air Currents, m/s	Sum	1.1	5.8	5.4	5.3	3.3	0.3	0.1-1.5	0.09-0.4	0.05	0.09-0.4
	Win	---	1.1	6.0	5.8	3.1	0.3	0.1-1.8	---	0.02	---

miners showed a slight increase in the number of cases in which the heating reaction exceeded 75 seconds (16 to 18%). On the other hand, only 7% of the control group showed after work a heating reaction greater than 75 seconds.

The first difference between miners and controls to emerge from our data is that even under conditions of rest outside the mine, the miners show disorders of the peripheral circulation appearing as a heating reaction greater than 75 seconds while only after work do some controls, because of specific microclimatic conditions in the pit, show a peripheral vasoconstriction appearing as a heating reaction greater than 75 seconds.

Noteworthy in this case, too, is the fact that, unlike workers who work with pneumatic hammers in foundrys, in whom the duration /199
of the heating reaction decreases at the end of work, in miners this reaction shows a tendency to increase, for which the explanation is the same as for skin temperature.

Vibratory sensitivity. In the investigated miners, the vibratory sensitivity threshold as a function of frequency was lowest for frequencies from 20 to 40 Hz (23-42 cm/s^2) and highest for frequencies above 300 Hz (456-767 cm/s^2). The majority of examined miners (90%) did not perceive vibrations with frequencies greater than 500 Hz. In the control group, on the other hand, vibratory sensitivity for frequencies above 500 Hz was present in a greater number of subjects (50%).

TABLE 4. SKIN TEMPERATURE BEFORE AND AFTER WORK, UPON ENTERING AND AFTER 10 MINUTES OF SITTING IN THE EXAMINATION ROOM (MEAN VALUES).

Group of Workers	Month of July						Month of November					
	Before			After			Before			After		
	Outside Temp.	Skin Temp.		Outside Temp.	Skin Temp.		Outside Temp.	Skin Temp.		Outside Temp.	Skin Temp.	
		Entering	After 10 min		Entering	After 10 min		Entering	After 10 min		Entering	After 10 min
Miners	18.7	26.9	28.2	15.9	27.6	29.9	11.4	26.4	28.4	8.5	26.4	28.2
Controls	18.7	28.3	29.7	15.9	29.1	31.2	--	--	--	--	--	--

TABLE 5. SKIN TEMPERATURE BY GROUPS OF VALUES IN MINERS (% OF CASES).

Time	November			July		
	Under 20°C	20-24 °C	24-31 °C	Under 20°C	20-24 °C	24-31 °C
Before work	2.6	17.5	79.9	-	5.9	93.1
After work	3.3	16.6	80.1	-	-	100.0

TABLE 6. HEATING REACTION BEFORE AND AFTER WORK (% OF CASES).

Group of Workers	Cases (%)			
	Below 75 sec		Above 75 sec	
	Before	After	Before	After
Miners	84	82	16	18
Controls	100	93	-	7

After work, the vibratory sensitivity threshold increased in 50% of the miners for frequencies from 20 to 25 Hz, which happen to be some of the dominant frequencies of the vibrations generated by the pneumatic hammers used in the mine for drilling and cutting; likewise, indetermining the transmission of vibrations to the workers' organism, we found that the greatest vibratory accelerations take place for low frequencies (Table 1). At frequencies between 31.5 and 600 Hz we found a drop in the vibratory sensitivity threshold after work in 22-76% of the miners, as a function of frequency, the highest percentaof drops (50-76%) occurring for frequencies of 100-500 Hz.

In subjects in whom vibratory sensitivity was present for frequencies above 500 Hz, the vibratory sensitivity threshold increased after work at frequencies of 800-1000 Hz in 80% of the cases. In the control group, on the other hand, the vibratory sensitivity threshold dropped for all frequencies, the greatest drops occurring for frequencies of 500-1000 Hz.

So our results show that miners have a lower vibratory sensitivity, especially for the higher frequencies.

Conclusions

It follows from our investigations that the pneumatic drill and pick hammers used in coal mines constitute an important source of vibrations that are transmitted directly to the workers who handle them; at the level of the upper limbs the parameters of these vibrations exceed the permissible limit values, especially for frequencies of 31.5 and 63 Hz, which cause vibration sickness. The transmission of vibrations is fostered by intense and static muscular contractions, as well as by the positions of the body necessary to support and direct the tool. The cold present in the pit under different forms (reduced air temperatures, cold air currents, high humidity, drilling water) fosters the appearance of vibration sickness. Consequently, measures to combat the harmful effects of vibrations must take into account several factors: attenuation of the vibrations inherent in the tool, improvement of the method of holding the tool, general and local individual protection (of miners) against the cold in their work space and in the galleries; an important factor in individual protection is waterproofing. /200

From the medical point of view, we can ask whether a number of disorders or affections localized in the upper limbs that have been diagnosed in pit workers as rheumatism, are not in reality manifestations of disorders of the peripheral circulation or osseous changes caused by vibrations. In addition, prophylactic or passive medical examinations must be accompanied by an anamnestic and objective investigation, including the examinations that are characteristic of vibration sickness.

Summary //201

The characteristics of vibrations and their transmission to the human organism were determined in the principal hand-operated pit tools, and physiological investigations were conducted of the effect of vibrations on the miners' organism (in the present case, their hands) as compared with pit workers who are not exposed to vibrations. We found that the vibrations generated by drill and pick hammers are transmitted to the upper limbs with values that exceed permissible limits, especially for frequencies of 31.5 and 63 Hz. The cold present in the pit fosters the effect of the vibrations.

The miners showed peripheral vascular spasms, which were the more pronounced and the more frequent, the lower the air temperature, as well as a drop in vibratory sensitivity, especially at frequencies above 500 Hz.

The authors discuss how to combat vibrations in the pit.

REFERENCES /200

1. Andreeva-Galanina, E.T., Vibratiile si importanta lor in igiena muncii [Vibrations and their importance in labor hygiene], Ed. Tehnica, 1958.

2. Cadariu, G., B. Barhad, N. Gavrilescu (edited), Igiena muncii [Labor hygiene], Ed. Medicala, 1967, pp. 170-215.

3. Cadariu, G., C. Gradina, H. Herman et al., Studii si cercetari de protectia muncii [Labor protection studies and research], Ed. Medicala, 1964, pp. 15-43.

4. Casula, D., G.P. Nissardi, et al., Lavoro umano 9, 412-443 (1967).

5. Dérobert, L., Intoxications et maladies professionnelles [Occupational poisonings and diseases], Ed. Flammarion, Paris, 1957.

6. Gavrilescu, N., I. Danila, H. Herman, and P. Danescu, Studii si cercetari de protectia muncii [Labor protection studies and research], Ed. Medicala, 1964, pp. 269-287.

7. Herman, H., I. Ionescu, V. Marinescu, and I. Grigoriu, "Research from the hygienic point of view on equipment for individual protection against vibrations," Studiu ICSPM (1968).

8. Paranko, N.M. et al., Gig. trudâ i prof. zab. 5, 14-16 (1967).

9. Pilat, L. and N. Gavrilescu (edited), Bolile profesionale [Occupational diseases], Ed. Medicala, Bucharest, 1966, pp. 497-521.

10. Scherrer, I., Physiologie du travail (Ergonomie) [Work physiology (Ergonomy)], Vol. 2, pp. 101-113.

RESULTS OF A SOCIOLOGICAL SURVEY OF THE EFFECT OF AIRCRAFT NOISE ON RESIDENTS NEAR OTOPENI AIRPORT

Simona Hetcou
Institute of Transportation Studies and Research,
Bucharest, Romania

The problem of annoyance due to aircraft noise is assuming /203
particular urgency throughout the world, and laying out airports near populated centers calls forth lively protests on the part of the affected population.

The problem is not new: it emerged all of a sudden with the advent of trains, evolving with the addition of trucks, buses and private cars; the problem increased still further with the construction of highways and speedways through quiet residential zones until it acquired an acute form with the establishing and extending of airports. All of these were created for the public good -- or at least that is what people think -- yet, taken separately, each one signifies a source of noise that, in spite of all efforts, could not be eliminated.

In addition, the noise pollution caused by aircraft in the course of flying or maneuvering on the ground differs from that due to street, industrial, and other types of noise in a number of respects. While the mean values of the intensity of the sound level for aircraft that are flying at an altitude of 800-1000 m can be on the same order of magnitude as those due to street traffic opposite windows facing an intensely traveled street, street traffic does not have peak values of the same sound intensity or frequency as air traffic around airports.

Protection against street noise can also be implemented more easily than against aircraft noise because of differences in their direction of propagation; the powerful spreading from top to bottom of aircraft noise is more difficult to limit through phonic insulation measures.

A number of attempts have been made to reduce noise at its /204
source, but this is a very difficult operation entailing great expenses, and its efficiency is limited; a reduction in noise by 4-9 dB is accompanied by a drop in driving efficiency, high fuel consumption, a decrease in the number of passengers transported, etc.

It has been proposed to issue obligatory "noise certificates," without which no aircraft could land.

In general, all the proposed solutions have turned out to be no more than palliative. This is all the more true, the more certain is the appearance of ever more powerful -- and, therefore, implicitly "noisier" -- aircraft, not to speak of supersonic aircraft.

Specialists have therefore proposed a zoning of the residential land around airports as a function of permissible noise limits. On this occasion, too, a number of difficulties emerged: in the first place, owing to economicosocial factors involving the high cost of land in towns and the absence of building space experienced by the great majority of the world's towns; in the second place, it is difficult to estimate the limits beyond which aircraft noise becomes noxious for the population and to establish in a practical manner the noise pollution of land around airports.

But while such zoning is effective and imperative in the case of airports that are going to be built, it is of limited usefulness in the case of those airports which are now functioning in the immediate vicinity of smaller or larger conurbations.

In the expectation of technological advances it is assumed that any provisional solution for conurbations will be but a compromise, and the conviction is gaining ground that in the future airports will be obliged to acquire adjacent zones, a good part of which will be earmarked for industrial purposes. Of course, the relocation of neighboring residences will be an extremely costly operation; it will, however, be a measure dictated by the extensive development of airports and aircraft, as well as by the difficulty that the residents will experience in carrying out their daily activities under conditions of a high noise level.

Surveys conducted around airports have established land-use zones with limits determined on the basis of the sound level in dB (A) and in PNdB. /205

For example, in Germany Reither has determined the following three zones around airports:

-- zone 1, with a noise limit of 72 dB (A) ($\overline{q}$), is situated right next to the airport and permits no construction of residences;

-- zone 2, 65 dB (A) ($\overline{q}$), permits construction only as a function of strict sociopolitical necessity, and then only in a "relaxed" construction style;

-- zone 3, 63 dB (A) ($\overline{q}$), is recommended for the construction of residences, with special soundproofing measures being adopted only in the case of hospitals, schools, etc.

E. Grandjean sets up four zones as a function of an "annoyance index" Q:

-- zone 1: Q index above 82;

-- zone 2: Q index between 72-82; zone with no inhabitants apart from airport personnel;

-- zone 3: Q index between 72-77; zone in which residences must be protected against noise;

-- zone 4: Q index of 72; zone with a residential character, but without hospitals, resthomes, etc.

The same author shows that the intensity of aircraft noise is intolerable if it exerts an influence over man's psychic well-being. This influence can be taken for granted if a large part of the population declares that:

-- aircraft noise disturbs their sleep, wakes them up, gives them a fright, they experience difficulty in falling asleep;

-- they cannot make each other out in conversation;

-- it makes them want to move.

From the physiological point of view, noise causes a number of changes, among which we might mention acceleration of the circulation, palpitations, a general alertness reaction on the part of the organism.

Psychically, noise contributes to formation of a sensation of anxiety and indisposition (depending on noise intensity and overflight frequency).

If aircraft noise exceeds a certain limit, it can interfere with radio and TV reception and cause damage to buildings. /206

In the specialty literature two methods can be found for establishing the influence of aircraft noise incident to flight, takeoff and landing, on the population's state of health and satisfactory fulfilment of life:

-- objective measurement of aircraft noise;

-- sociological surveys for establishing subjective inconveniences.

As part of the study we conducted at Otopeni Airport, we measured the noise in different zones of the runway, incident to landing and takeoff; in the surrounding inhabited zone; and under the airport's passageway. We used the method of numerical determination of noise emission values on the basis of data about the mean overflight level, the frequency of scheduled flights and the direction and angle of flight. Most useful are the repeated measurements (per year and per day), measuring background noise as well.

The sociological survey was conducted in eight localities situated at distances ranging from 3 to 15 km from the airport, as follows: Balotesti (5 km); Gradistea (15 km); Fierbinti (13 km); Tunari (3.20 km); Otopeni (3.30 km); Corbeanca (6 km); Diminei (3.2 km); Taras (8 km).

The localities were selected on the basis of their position and distance from the runway; thus, Dimieni and Tunari are located on either side of the runway; Tamas and Corbeanca are situated opposite the runway, in the landing direction; the other localities occupy no special position with respect to the runway but, being very close to the airport, they are assumed to be strongly influenced by aircraft noise (see map).

The methods we used were as follows: direct observation, discussions with executive officers and teaching staff, questionnaires addressed to residents.

The questionnaires were aimed at ferreting out the attitude of residents toward the existence of an airport close by and, therefore, toward aircraft noise; inconveniences as regards the human organism; comfort; animal behavior; influence on buildings, /207
communications media and schoolchildren's grades; and whether these inconveniences are big enough to warrant moving out of the neighborhood.

As a matter of fact, there is really no way to determine, with reference to an absolute standard, the level at which the annoyance caused to collectivities by aircraft noise would have to be regarded as intolerable; this level would have to be determined by comparing reactions to aircraft noise with reactions to other sources of noise and, also, by measuring the noise level in those zones in which the greatest number of cases of annoyance to the population can be ascertained.

In interpreting the survey results account is taken of the influence of psychological factors on the final result of the action of noise inasmuch as people's psychic reactions have their origin not only in their keenness of hearing but also in the information content of the sounds, to which a contribution is made

by memories stored in the unconscious as a result of former situations, as well as by the disposition at the time this reaction appears and unfolds. The combined action of sensory impressions, information processing, the reason and the will in triggering noise-induced reactions, leads to an attitude of "polarization" with respect to the cause or source of noise which, in the case of aircraft noise, acts either positively, as when it captures the attention, or negatively (in most cases), as when it is rejected and recorded as an annoying excitation.

Individual differences with respect to noise range from "noise allergy" to "noise resistance."

In correlating the disorders acknowledged by the persons surveyed (loss of hearing, loss of memory, diminished attention, nervous insomnias, vertigo, fatigue, loss of appetite, headache, etc.) with age, profession, work space (with or without noise), family history of loss of hearing and the accident that caused the deafness, it can be inferred that the most important parameters in the appearance of these disorders are as follows: on-the-job noise and aircraft noise. This confirms the validity of our working hypothesis that the repercussions of aircraft noise on the physiological equilibrium of residents will be the greater, the better the statistical data express a direct correlation between the date of appearance of this phenomenon and the moment the airport went into operation (see table). /208

But let us mention that this was not frequent, and our results are based only on the sounding out of a random sample of population.

In general, the airport neighborhood does not display a clearly hostile attitude. Aircraft noise does not seem to have any effect on the learning process, nor repercussions of any other kind (damage to buildings, influence on animals); frequently disturbed, on the other hand, is radio and TV reception.

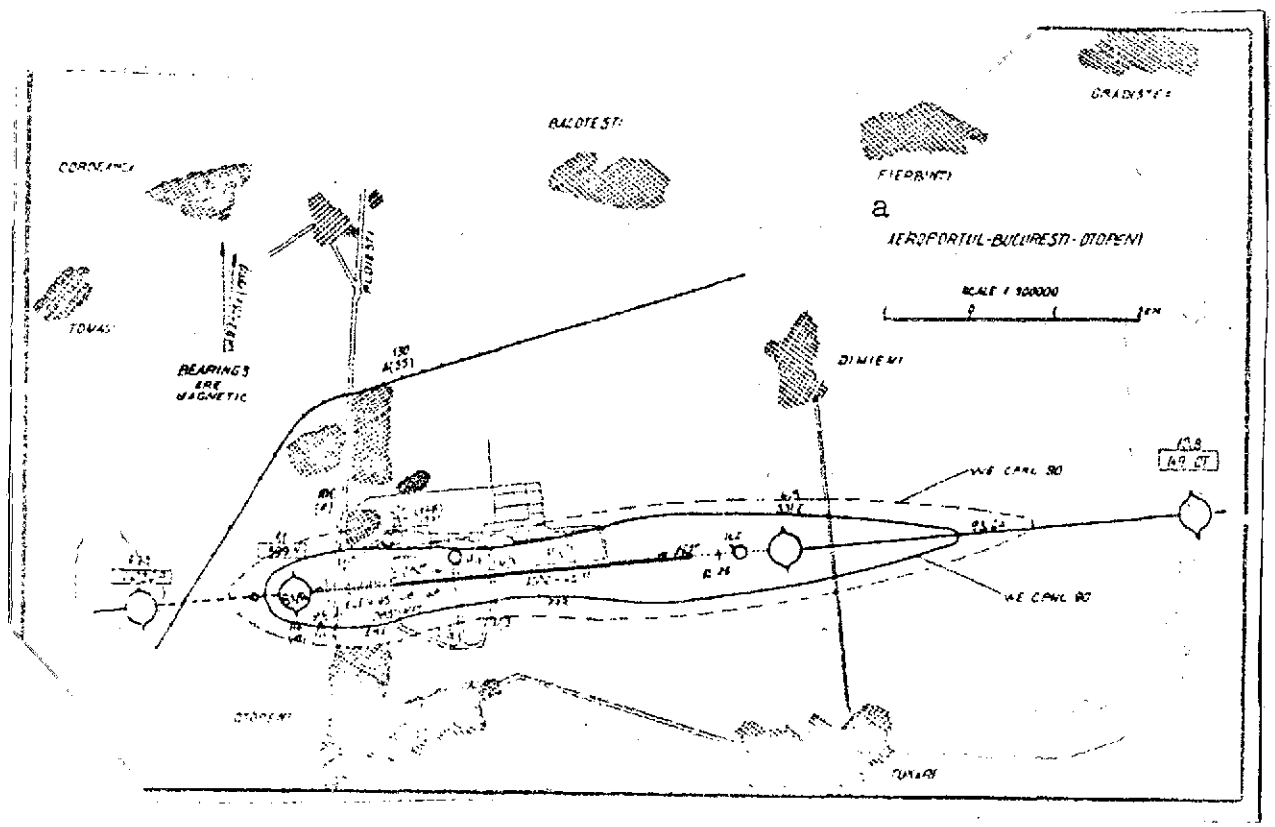
At the present time, when air traffic at Otopeni Airport has not reached alarming proportions, the level of aircraft noise does not exceed tolerable limits and, consequently, in the course of the sociological survey conducted in the neighborhood of the airport nothing special was found to point to physiological or psychosocial disturbance or disequilibrium.

The purpose of sociological research, however, should not be merely catalogic, with the possible aim of instituting therapeutic action at the social level; sociological research should be imbued with predictive value for the subsequent development of social phenomena on the basis of present trends. Thus, while at the present time Otopeni Airport does not make its presence felt

except to a small extent, its subsequent development and increasing air traffic will lead to an increase in the quantity of noise to which residents will be exposed and in the length of noise exposure, with foreseeable consequences for the human organism and its psychosocial equilibrium.

Prevention of such phenomena is predicated on the working out of plans for the systematization of localities around airports, delimitation of constructions and even uprooting of those localities which -- from the standpoint of the developmental plans for the airport -- will enter into a zone with an unacceptable noise level.

/209



Map of Otopeni Airport and neighboring localities.

Key: a. Bucharest/Otopeni Airport

Reproduced from best available copy.

STATISTICAL DATA FROM A SURVEY OF A SAMPLE POPULATION RESIDING AROUND OTOPENI AIRPORT.

Do you hear well?	Yes									
	No									
	Relatively									
Since when have you been aware of physiological disorders?	1-2 years									
	3-4 years									
	5-6 years									
	7-8 years									
	9-10 years									
Since when have you been hard of hearing?	1-2 years									
	Above 10 years									
	No answer									
Are you annoyed by aircraft noise?	Yes									
	No									
	Sometimes									
	No answer									
Does aircraft noise interfere with radio, TV reception?	Yes									
	No									
	No answer									

Summary /211

The placement of airports in urban areas has become one of the world's most urgent problems because of the annoyance that aircraft noise causes to local residents.

Research conducted in localities around Otopeni Airport aims at detecting the inhabitants' attitude toward noise pollution, possible physiological and psychological effects, and socio-professional changes which could occur as the result of airport construction.

Unalarming as these results are, they suggest some problems that must be taken into consideration in planning for airport expansion, as well as in planning for systematization of localities around airports.

REFERENCES

Quercy, J.V., "Protection of ground personnel against reactor noise," Arch. des Maladies Prof. 6, 537 (1966).

Grajdanskaja, A., "Limitation of aircraft noise," Rev. Aviatia 2, (1970).

Matsui, K. and H. Sakamoto, "The understanding of complaints in a noisy workshop," Ergonomics 1, 95 (1971).

Statescu, Adriana, "Some problems of airport noise pollution," Rev. Igiena 11 (1972).

--, "Annoyance caused by airport noise," Rev. d'Acoustique 10 (1970).

--, "Effects of noise and the fight against noise," Coll. d'Hyg. et de Méd. du Travail 7 (1967).

Hilscher, J., "Method of establishing restricted construction zones in the vicinity of commercial airports," Verkehrsmedizin 7 (1972).

Grandjean, E., "Air traffic noise requirements," Revue d'Acoustique 2 (1970).

Bitter, C., "Annoyance due to aircraft noise," Revue d'Acoustique 10 (1970).

Leverton, G.W., B. Tech, Mac Eng [sic], "Rotocraft for diminution of annoyance due to aircraft noise," Rev. Aircraft Engineering 3 (1972).

SIGNIFICANCE OF OCCUPATIONAL NOISE EXPOSURE IN A WIRE NETTING MANUFACTURING DEPARTMENT

C. Ursoniu, A. Dankner, I. Bodea, and A. Sirbu
Timisoara Institute of Medicine,
Center of Medical Research, Timisoara, Romania

Industrial noise constitutes one of the most frequent noxae encountered in the machine-building industry. /213

Our research, which was conducted in departments for the manufacture of wire netting with different industrial uses, sought to bring to light auditory changes in workers exposed to occupational noise.

Research Methods Employed

1. Measurement of sound intensity with a 3501 Brüel and Kjaer sonometer. We determined total noise intensity as well as the intensity in different frequency ranges by plotting audiospectrograms.

2. Exploration of the auditory function with an Atlas audiometer. The measurements were carried out before the start of work in order to avoid the effects of noise exposure during working hours.

Research Results

1. Measurement of noise intensity in some work spaces showed the presence of exceptionally intense noise, which sometimes reached 109 dB.

Audiospectrographic plotting brought to light the aspects shown in Figs. 1-4. It can be seen that the Cz 85 dB curve is exceeded in the 500-1600 Hz frequency range.

2. Audiometric examination of 220 workers exposed to occupational noise in wire netting manufacturing departments showed the presence of audiometric tracings that are characteristic of occupational deafness in 29.5% of the persons examined. /214

The significance of the length of exposure to occupational noise is illustrated by the presence of these audiometric changes in only 25% of the workers with a length of service less than 15 years as compared with over 40% of those with a length of service greater than 15 years. Figures 5, 6 and 7 show the audiograms of workers with different lengths of service. /215

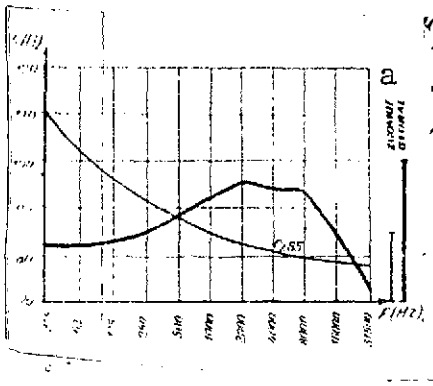


Fig. 1.

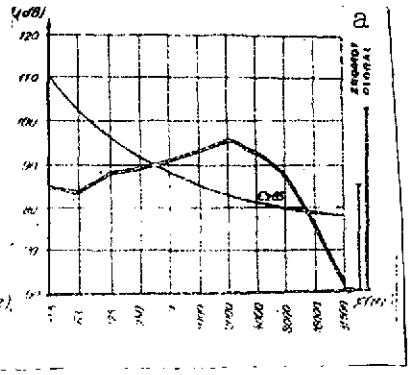


Fig. 2.

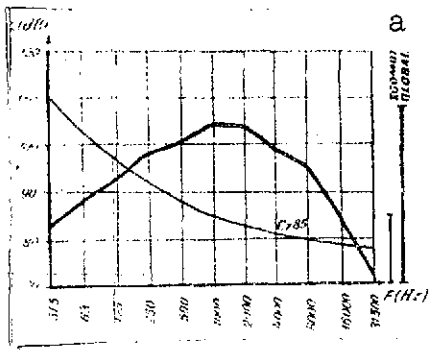


Fig. 3.

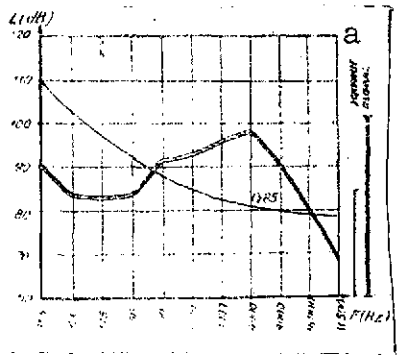


Fig. 4.

General key: a. Total noise

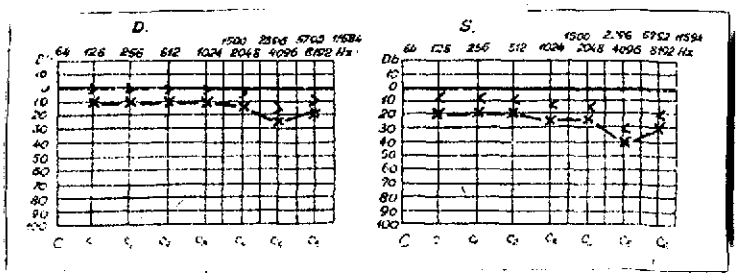


Fig. 5. M.M. 32 years. Length of service: 9 months.

Discussion of Results /216

Industrial noise is the most frequent and best known cause of "perception deafness" (also called "occupational deafness"), which was described for the first time in boiler room workers. In order to prevent the appearance of this sickness it is estimated that the noise intensity during work must not exceed 90 dB/(A) or the Cz 85 dB recommended by hygienic standards.

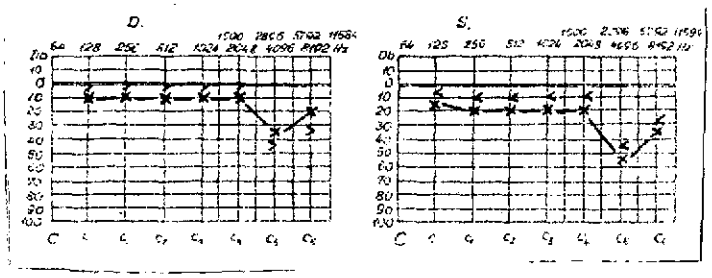


Fig. 6. L.S. 30 years. Length of service: 4 years.

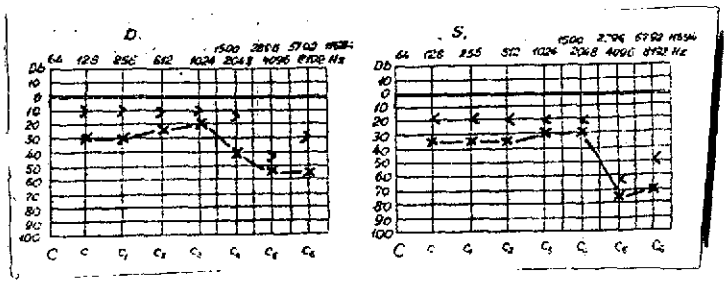


Fig. 7. E.S. 43 years. Length of service: 10 years.

Occupational exposure to noise in the departments in which we conducted our research is especially significant: the noise intensity in different frequency ranges varies within rather wide limits, the highest values being encountered in the 5000-16,000 Hz frequency range.

Total noise intensity has likewise attained increased values, up to 109 dB.

The influence of this exceptionally intense noise on the auditory function is illustrated by the presence of the audiometric curves that are characteristic of occupational deafness in about 30% of the workers examined.

The different incidence of these tracings as a function of length of service brings to light the exceptional importance of the length of time that the sound aggression acts on the organism.

In most of the persons examined, the tracing that is characteristic of occupational deafness was encountered at frequencies of 4096 Hz. In some cases this also involves frequencies close to 2048 Hz, 1024 Hz and 8192 Hz, especially in workers with a greater length of service.

Conclusions

1. In wire netting manufacturing departments, there exists considerable occupational exposure to noise that exceeds Cz 85 dB in the 500-16,000 Hz frequency range. Total noise intensity sometimes reached 109 dB.

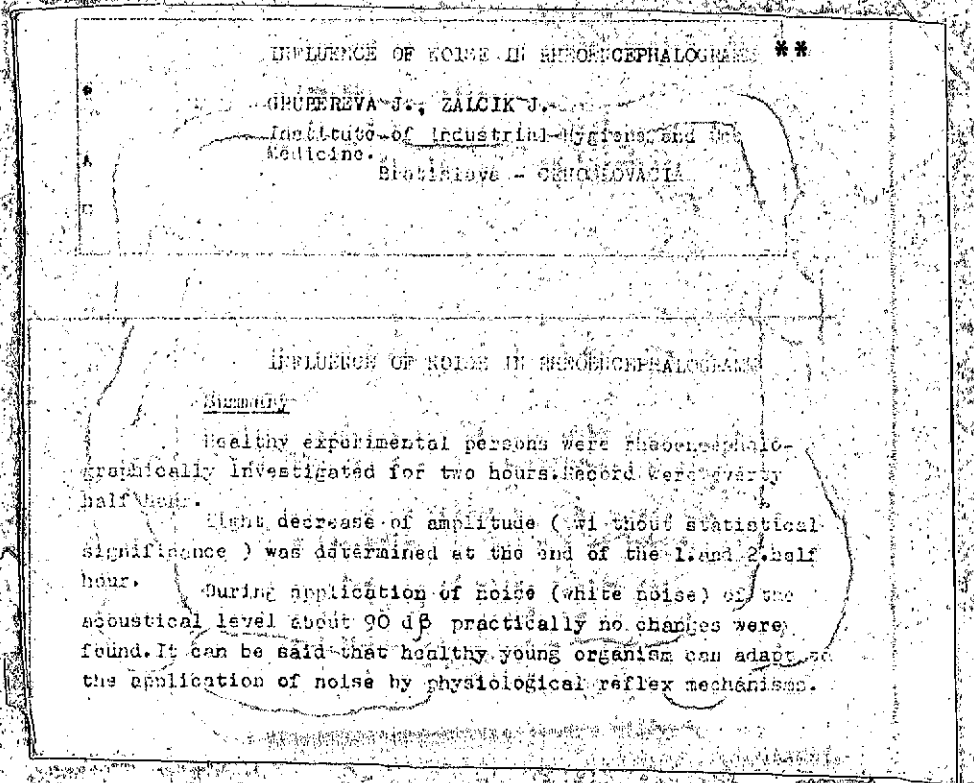
2. Audiometric examination of 220 workers exposed to occupational noise brought to light in 29.5% of those examined, the presence of the audiometric tracings that are characteristic of occupational deafness. /217

3. The importance of the length of exposure to occupational noise is illustrated by the presence of these audiometric changes in 25% of the workers with a length of service less than 15 years and in over 40% of those with a length of service over 15 years.

4. These results show that the hearing of the workers examined was significantly affected, a fact that enjoins careful study of ways and means to reduce noise in the course of the technological process in this department.

Summary /218.

Research was conducted in a department for the manufacture of wire netting with different industrial uses. Measurement of noise intensity with a Brüel and Kjaer sonometer showed the presence of a total noise that sometimes reaches 108-109 dB. Cz 85 is exceeded in the 250-16,000 Hz frequency range. The audiometric plotting for 220 workers showed the presence of some audiometric tracings that are characteristic of occupational deafness in 29.5% of the workers examined. The importance of the length of occupational exposure to the action of noise is illustrated by the presence of these audiometric changes in only 25% of the workers with a length of service less than 15 years as compared with 40% of those with a length of service greater than 15 years. Our results show the extent of occupational exposure to noise in this production sector.



INFLUENCE OF NOISE IN ENCEPHALOGRAMS **

GRUBEROVA J., ZALCIK J.

Institute of Industrial Hygiene and Medicine.

Bratislava - CZECHOSLOVAKIA

INFLUENCE OF NOISE IN ENCEPHALOGRAMS

Summary

Healthy experimental persons were rheoencephalographically investigated for two hours. Record were every half hour.

Light decrease of amplitude (without statistical significance) was determined at the end of the 1. and 2. half hour.

During application of noise (white noise) of the acoustical level about 90 dB practically no changes were found. It can be said that healthy young organism can adapt to the application of noise by physiological reflex mechanism.

REFERENCES /217

1. Hickish, E.E., "Industrial noise (report)," Ergonomics and physical environmental factors, I.L.O., Geneva, 1970, pp. 73-96.

2. Mounnier-Kuhn, P. and J. Bonnefoy, "Industrial noise and the auditory apparatus," Journal de Médecine de Lyon, XI/20, 933 (1958).

3. Quaas, M., "Noise as a general exogenic stress factor of the organism," Ergonomics and physical environmental factors, I.L.O., Geneva, 1970, pp. 150-154.

4. Ursoniu, C., N. Puca, A. Dankener, and I. Meila, "Some aspects of occupational exposure to noise in the machine-building industry," Activitatea stiintifica [Scientific Activity], Institutul de Medicina Timisoara, 1970, p. 715.

5. Ursoniu, C., A. Dankner, N. Puca, G. Silas, T. Cicara, L. Lipovan, "Some aspects of stresses to the organism in the textile industry," Timisoara Medicala 1, 47-52 (1971).

EXPERIMENTAL RESEARCH ON THE ROLE OF AMPLIFIER OF THE BULLA TYMPANICA IN ANIMALS

Dezideriu Holicska and Zoltan Kis
Polyclinic of Companies, Cluj, Romania

The role of the pneumatic cavities of the middle ear (m.e.) /219 still constitutes an object of discussion. In man, these cavities are represented by the antrum and the mastoid system. The great variations in size, number and shape of the mastoid cells prevent us from drawing a general conclusion about the role and mode of operation of these cavities. In some animals, this system of cells is represented by a much more uniform anatomical formation called the bulla tympanica (b.t.), which is therefore much more suitable for experimental research aimed at elucidating the role of these cavities. In some animals (cat, hare, guinea pig, etc.), the b.t. consists of a single cavity; in others (dog, mink, fox, etc.), it is divided by incomplete bony septa into two or more cavities that communicate extensively with one another. In certain cases the b.t. gets to be surprisingly large (the American desert rat, psammomys obesus).

Because the b.t. is present in some animals considered to possess pronounced auditory acuity, some of which have no other means of defense than keenness of hearing and rapidity of movement, from the very outset we posited a causal relationship between the presence of the b.t. and the developed hearing of these animals.

As regards the role of these cavities, the specialty literature /220 is relatively silent and opinions differ. At the present time two conflicting views can be discerned: according to some authors, the b.t. plays the role of a damper that behaves, by virtue of the air it contains, like an elastic cushion that protects the fragile elements of the tympanic box or membrane from too violent variations in pressure while according to others, it plays the role of an acoustic resonator. Many authors, on the other hand, maintain that the role of the b.t. has not been clarified at all.

We assume that the b.t. plays a role in sound amplification. Owing to this function, animals equipped with these formations can hear sounds of such low intensities that they are imperceptible to the human ear, which enables them to defend themselves better against their enemies (small animals such as rodents and herbivores) or hunt their prey (carnivores, especially felines), thereby assuring the continuity of the species.

If the b.t. had no other role than that of a damper, as some authors maintain, it would not be possible to explain why some animal species possess this formation while others, which live under the same conditions, do not. On the second view, violent pressure changes would traumatize the organ of hearing of the animals that are not equipped with this anatomical formation.

In order to demonstrate the role of amplifier of the b.t., we thought up the following experimental procedure: exciting the organ of hearing with a sound stimulus of 3000 Hz and an intensity of 80 dB, bioelectrical phenomena called cochlear microphonic potentials (CMP) can be recorded by means of a platinum electrode placed and fixed on the membrane of the fenestra rotunda. These biolelectrical currents, when they are passed through a preamplifier, give rise on a cathode-ray oscilloscope screen to pulses of a certain magnitude (3-4 cm). Suppressing the cavity through occlusion of the b.t. with duracryl and excitation of the ear with the same stimulus, the magnitude of CMP drops to 1/2 - 1/3 of their initial value. /221

The operation is conducted under general anesthesia with an intraperitoneal 10% urethane solution, under an operation microscope, in a room screened against interferences. We used an audiofrequency preamplifier with an amplifying power of 1000. Recording was effected by means of a low-frequency cathode-ray oscilloscope (Orion 4101). The sound stimulus was produced by a pulse generator with frequencies of 50-10,000 Hz (Orion Tr.-0401). Excitation was effected by the free-field method.

We conducted a series of ten experiments on cats, which are animals with a rather large b.t. and a fenestra rotunda that is very suitable for the placing and fixing of an electrode.

Conclusive results were obtained in nine of the ten experiments. In a single case, owing to a technical defect consisting in accidental perforation of the membrane of the fenestra rotunda, we were obliged to interrupt the experiment, the result in this case being unsatisfactory.

Summary /223

The bulla tympanica, which is a cavitary formation belonging to the middle ear of some mammals, plays the role of a sound amplifier which amplifies the sounds that impinge on the tympanic membrane, so that these animals can perceive sounds of very low intensities, even sounds that are imperceptible to the human ear. The authors demonstrate experimentally in the cat the stated hypothesis by recording cochlear microphonic potentials by means

of a platinum electrode placed and fixed on the membrane of the fenestra rotunda before and after occlusion of the bulla tympanica with duracryl. After suppression of the cavity through occlusion, the cochlear microphonic potentials drop to 1/2 - 1/3 of their original value for excitation with a stimulus of the same frequency and intensity (300 Hz and 80 dB).

REFERENCES

Békesy, C.V., Experiments in hearing, McGraw Hill Co., New York, 1960.

Elliott, D.N., L. Stein, and M.J. Harrison, "Determination of absolute intensity and frequency difference thresholds in cats," The Journ. of the Acoust. Soc. of Amer. 32/3, 38.

Grassé, P.P., Traité de Zoologie. Anatomie.Systematique. Biologie [Elements of zoology. Anatomy. Systematics. Biology], Vol. XVII, Masson et Cie., Paris, p. 1374.

Holicska, D., A. Vaida, "Anatomicosurgical considerations on the middle ear in man and some mammals," Oto-rino-laringologia (Bucharest) VIII/1 (1963).

Holicska, D and Z. Kis, "Studies of some morphofunctional characteristics of the middle ear in man and cats," Studii si cercet. Biol. Seria Zool. 23/2 (1971).

Lawrance, Merle, "Middle ear mechanics and surgery for deafness," The Journ. of the Acoust. Soc. of Amer. 34/9, Part 2 (1962).

Legouix, J.P., "Changes in the cochlear microphonics of the guinea pig produced by mechanical factors in the inner ear," The Journ. of the Acoust. Soc. of Amer. 34/9, Part 2 (1962).

Legouix, J.P., F. Petter, and A. Wissner, "Study of hearing in mammals with a hypertrophic bulla tympanica," Mammalia 18/3, (1954).

Legouix, J.P. and A. Wisner, Rôle fonctionnel des bulles tympaniques géantes de certains rongeurs (mériones) [Functional role of the giant bullae tympanicae of certain rodents (merinos)], Vol. 15, Acustica, S. Hirzel Verlag, Zurich, 1955.

Mygind, S.H.,"Functional mechanism of the labyrinthine epithelium," Arch. Otolaryng. 82, (Nov. 1965); 83, (Parts I, III, III (1966).

Werner, C.F., Das Gehörorgan der Wirbelthiere und des Menschen [The organ of hearing in vertebrates and man], Veb. Georg Thieme, Leipzig, 1960.

Zavattari, E., "Essay on physiological interpretation of the hypertrophy of the bulla tympanica of mammals of the Sahara," Mammalia 4.

ASPECTS OF SOUND AND VIBRATION POLLUTION WITH PATHOLOGICAL IMPLICATIONS IN PRAHOVA COUNTY

Alexandru Stefaniu and Gheorghe Caluschi
State Sanitary Inspectorate, Plaresti, Romania

Among the noxious factors that cause occupational diseases /225
in the industrial enterprises of Prahova County, noise and vibrations occupy a prominent place. Then again, in some enterprises these noxae are compounded by others that overstress the organism in all of its functions. In view of the multitude of occupational etiologic factors, we believe that the number of occupational diseases detected and declared within the precincts of Prahova County is very small, which is not consistent with the facts.

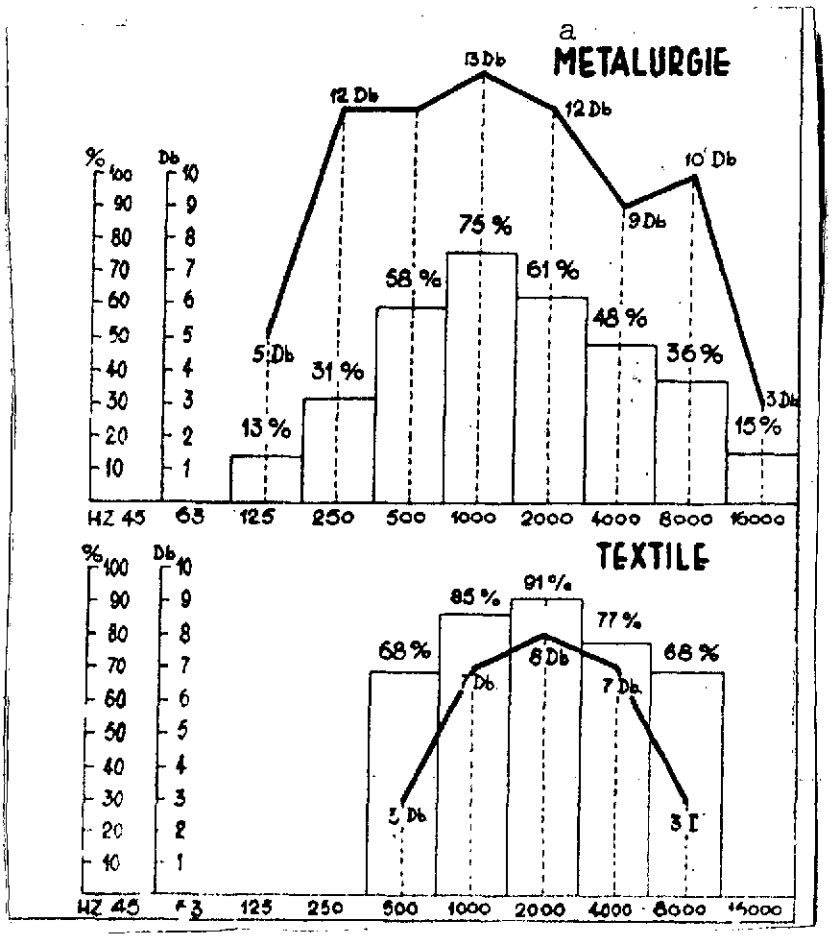
The purpose of the present study is to point up this situation and show that it is necessary to improve the manner of detecting these diseases through better staffing and equipping of the competent services, better understanding of harmful working conditions and adoption of a unified research, diagnosis and attitudinal methodology.

In Prahova County there are about 3500 workers who are exposed to sound trauma. In 34% of the work spaces investigated, the level of noise to which these workers are exposed exceeds the sanitary standard by values that range from 3 to 33 dB. It should be noted, however, that in the remaining 66% of work spaces, in which the noise level is below the sanitary standard, it is still high enough, often being scarcely 3-4 dB below the standard, and we believe that this situation cannot but be prejudicial to the health of the workers in question.

The figure below is a comparative analysis of the results of 300 determinations of cases of noise above the sanitary standard in metallurgy and textiles that we undertook with a device with ten frequency bands. /226

Thus, in metallurgy, the sanitary standard is most frequently /227
exceeded on the 1000 Hz bands, followed by the 500 and 2000 Hz bands, unlike the case of textiles, where the excesses keep approximately to the same level, and even on the 2000 Hz bands the excesses in textiles are found in 91% of the work spaces investigated. As regards excesses in dB, which are represented by a continuous line, they are much more pronounced in metallurgy, on all frequency bands.

The upshot is that the noise to which women workers of the textile industry are exposed does not have a very great intensity, puts in an appearance only on frequency bands included between



Noise above the sanitary standard.

Key: a. Metallurgy

500 and 8000 Hz and, in conjunction with other noxious factors, can constitute a point of departure for determining the general disorders that these women workers evince in contradistinction to workers from metallurgy, where the noise intensity is much greater, on all frequency bands, with severe and explicit effects on the faculty of hearing, but without disorders of a general nature.

In view of this situation, the efforts to detect occupational diseases of the organ of hearing in our county appear to fall short of the mark. Thus, in 1971, 11 cases of hypoacusia were declared per 100,000 Romanian workers in general while in our county, in the course of 10 years, 3-4 cases per 100,000 workers were declared annually. This does not mean that we have no cases of hypoacusia, as is proved by the fact that where they have been studied, they have been found in the proportion of 22.1 per 100,000 in a factory and 37.9 per 100,000 in a refinery.

Inescapable, therefore, is the necessity for mass detections with the aid of audiometry to be better organized, as well as the necessity for the otologist to collaborate with the neurologist, internist, gynecologist and psychologist, in order to determine synthetically the state of health of the workers. The fact is that with the aid of audiometry the otologist can only determine the degree of the hypoacusia; before the onset of the hypoacusia, however, some workers exposed to noise show a state of fatigue and a reduction in the organism's general resistance, states that cannot be determined by the otologist. Mobilizing three to four more specialists around a worker at the time of the periodic medical examination becomes impossible in practice. Consequently,

it has become necessary to create the specialty of Labor Medicine, the competent physician knowing how to synthesize all adaptation disorders under the cumulative effect of noxae, in which sound trauma predominates. /228

Thus, for example, in the compressor station of a petrochemical plant, the noise exceeds 90 dB on some frequency bands; but here the workers are not exposed to any other noxa. They work under very good microclimatic conditions and put out no physical effort. We studied the state of adaptation of these workers and found it to be excellent, exempt as it was from any disorder. In a flax and hemp weaving mill, on the other hand, where the noise level is much lower but the temperature and humidity are high and the women are exposed to the vibrations of looms as they work with uncomfortably bent bodies, overstressed vision and concentrated attention, they show, in addition to slight hypoacusias, a drop in the organism's general resistance, which is expressed in a morbidity involving a temporary inability to work that is almost twice as great as in the case of the preceding workers. Some of these women, characterized by little psychic adaptability, in time fall prey to psychasthenic states involving a prolonged inability to work, and sometimes they even quit their job.

It is known that vibrations not only foster the appearance of sound trauma [1], even if the noise does not exceed 50-60 dB, but are also detrimental to pregnancy; yet these women, beginning with the 6th month of their pregnancy, are exempted only from the night shift in order to avoid overworking; but they are not exempted from work spaces with vibrations, for which reason they sometimes give birth prematurely.

It would be interesting to follow the development and behavior of the product of conception when it has been subjected to the influence of noise and vibrations in intrauterine life.

For several decades the sound trauma and vibration problem has inspired studies and discussions, and it continues to do so; nevertheless, it should be recognized that up to the present time too little has been done from the prophylactic point of view because the accent has been placed on individual prophylaxis, which has turned out to be inefficient.

Then again, the prehiring examination must become more discriminating and less "pro forma." It is logical that individuals with a history of ear affections or a particular sensitivity of /229 the auditory apparatus detected on the occasion of periodic examinations, should be excluded from admittance to these work spaces. As far as the female sex is concerned, those with a personal or family history of a neuropsychic nature should be

excluded from admittance to weaving mills, or should be supervised in a special manner.

Inasmuch as medical assistance is based on collective as well as individual prophylaxis, we must strive, if not for the complete elimination, then at least for the diminution of noise as well as vibrations in enterprises. In this connection it is necessary that all those who have a social responsibility (we are referring in particular to the managements of industrial enterprises) be enjoined to take up the serious study of the noise and vibrations that are so injurious to workers.

Since some improvements have been achieved in the matter of urban noise by prohibiting honking, and some Soviet researchers, hygienists and architects have recommended a number of urbanistic solutions for combating sound pollution in the streets [2], we hope that the tens of thousands of technical inventors throughout the world will also arrive at some valid solutions for diminishing noise and vibrations in different productive enterprises.

Summary /230

After 300 determinations of noise with the aid of an apparatus with ten frequency bands, the authors found that the sanitary standards are exceeded in 34% of metallurgical work spaces, on all bands, more frequently on the 500, 1000 and 2000 Hz bands, with implications for hearing. Nevertheless, inasmuch as the workers are not exposed to any other noxa, the state of adaptation of their organism is excellent.

In a weaving mill, on the other hand, in spite of the fact that the noise level could be taped on much fewer bands (between 500 and 8000 Hz) and its intensity was lower, the weavers showed a drop in the general resistance of their organism, which was expressed in a psychasthenic state involving a temporary inability to work because of a plurality of noxae such as: noise and vibrations of looms, high temperature and humidity, concentrated attention, overstressing of the sight. Pregnant weavers, moreover, often give birth prematurely. Prophylactic measures must be taken to diminish noise and vibrations.

REFERENCES

/229

1. Apostol, N., "Acoustic trauma," Oto-rino-laringologie 11, Ed. Medicala, Bucharest, 402 (1964).

2. "Sound pollution," Meridiane, Muncitorul Sanitar 8, 4 (Nov. 11, 1973).

INVESTIGATION OF CITY NOISE IN TIRGU MURES

P. Horvat, E.I. Farkas, I. Steinmetz, A. Bodis,
W. Lücke, B. Ember, and P. Ney
State Sanitary Inspectorate, Tirgu Mores, Romania

The hygienic environment of modern urban settlements cannot /231
be characterized in our day without describing noise conditions.

Recognizing the sanitary importance of this modern noxa, specialized bodies of the United Nations, especially the World Health Organization, have included among their primordial preoccupations the prevention and combating of noise. Well-known is the fact that noise also has economic implications, unfavorably affecting as it does the state of health of the masses.

Out of 5.1 million persons interviewed in the course of a public opinion poll conducted in the German Federal Republic, 2.7 million declared that they were upset by noise for the greater part of the day and 2.1 million blamed noise for disorders of a psychic nature.

In Romania -- as is well known -- legal measures were adopted for the reduction of the noise level (a ban on honking in urban centers, the zoning of noisy enterprises, etc.), a great part of which appeared as a result of studies and debates that took place at the three National Conferences on the War against Noise which were organized under the auspices of the Academy of the Romanian Socialist Republic. Recently, a bill dealing with the protection of the environment appeared which contained articles referring to noise pollution.

In the last 2 decades, the town of Tirgu Mures, too, as in the case of other populated centers, has undergone spectacular changes. In a relatively short period this center with a provincial character, which was not settled so long ago, has doubled its population, exceeding 100,000 inhabitants.

This growth has entailed "metropolitanized" traffic. /232

Of course, the municipal administration was not able to keep up with this development in terms of widening of streets, extending of green belts, etc.

This has led to problems of restructurization and reorganization of traffic, attempts to decongest some streets and the like. Relatively meager have been the measures adopted with a view to attenuation of the noise due to different vehicles and the creation of sound-absorbing zones on the basis of studies in this direction.

With this situation as our starting point we embarked on a 3-year (1970-1972) study of the distribution and extension of noise in the town of Tirgu Mores.

Research Method

For the purpose of analyzing the noise sources and the more important factors that play a role in the generation of this noxa, after some tentative determinations we delimited certain zones in the town in which we set up permanent measuring points and polling points.

At these points we conducted noise measurements in different seasons of the year and at different hours of the day, placing particular emphasis on peak hours of traffic.

These measurements were recorded on specially designed filing cards. On the card appear the number and type of vehicles participating in the flow of traffic opposite the measuring point in a given period of time.

Measurements were conducted with a P.S.L. 201 R.D.G. apparatus and a Z.K.M.-2 R.S.C. "Tesla."

In the 3rd year of our study we conducted a public opinion poll about different problems raised by metropolitan and residential noise. To this end 3% of the population were sent postcards with a simple questionnaire consisting of 12 questions with reference to the annoyance caused by noises from different sources. This self-recording opinion poll was statistically processed electromechanically with punched cards.

Results

/233

In essence, the data we gathered disclosed that the exhaust system of municipal buses generally constitutes the principal and most intense source of street noise. In arterials and streets traveled by trucks as well as buses, the noise level attains its highest values. Thus, in the main arterial that connects the industrial zone with the center, the mean level is 90 dB during peak hours of traffic.

Another factor that fosters the generation of noise is inclined streets, where the noise generated by buses, although the number of buses plying the street per unit of time is half as great as that of the main arterial, not only attains, but even exceeds the value of 90 dB.

In quiet zones without buses, where only pickup trucks and private cars are to be found, such as a hospital zone, the mean noise level drops to 50-60 dB. Other quiet zones are constituted by those interior to some new residential neighborhoods that are also closed to bus and truck traffic.

These zones, however, are very much disturbed accidentally by noisy motorcycles and scooters, as well as by inappropriately located children's playgrounds, which produce sound maxima.

Of the many data and correlations emerging from the opinion poll, let us mention the following:

36.38% of all noises are generated in the morning hours up to 10:00 a.m., 37.70% in the afternoon up to 7:00 p.m., and 25.95% after 7:00 p.m.

According to the public opinion poll, the greatest annoyance is caused by the noise generated by trucks and motorcycles in 14.93% of the total noise generated in the town.

These subjective data agree with the objective measurements.

Consequently, without drawing any conclusions we can note the desirability of emergency measures for regulating and standardizing the maximum noise level for vehicles participating in the flow of traffic.

From the short-range as well as the long-range point of view, /234
a necessity of the first rank is to improve the soundproofing of buildings in order to prevent sound energy from penetrating from the outside to the inside. The competent bodies should decide in each case and from the acoustic point of view where to place public buildings, parking lots, noisy enterprises, playgrounds and other such noise-generating sources.

Summary

/235

The authors carried out a 3-year (1970-1972) study of noise conditions in the town of Tirgu Mures, which has doubled its population in the last 20 years. In the 3rd year of this study a public opinion poll was conducted by sending postcard questionnaires about noise annoyance to 3% of the population.

It was found that the principal source of noise is buses and trucks. Annoyance is distributed as follows: 36.38% in the morning, 37.70% in the afternoon, and 25.95% in the evening.

Reproduced from best available copy.

**The text of all articles written in English has been reproduced from the original book.